A QUARTERLY JOURNAL OF METHODS AND INFORMATION FOR TEACHERS OF SCIENCE

The SCIENCE COUNSELOR

Volume XIX ★ Number 4 ★ Dec., 1956

DUQUESNE UNIVERSITY PRESS

The Science Counselor

"FOR BETTER SCIENCE TEACHING"

A QUARTERLY JOURNAL *of teaching methods and scientific information especially for teachers of science in Catholic schools. Indexed in the Catholic Periodical Index. Published at Duquesne University, Pittsburgh, Pennsylvania, in March, June, September and December by*

DUQUESNE UNIVERSITY

Subscription Price: $2.00 per year; Canada, $2.25. Single copies of issues in the current year, 60¢ each.
Business and Editorial Offices at Duquesne University, 901 Vickroy Street, Pittsburgh 19, Pa.

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The Occurrence of the Common Elements

• By L. M. Foster, Ph.D., *(Brown University)*
ALCOA RESEARCH LABORATORIES, ALUMINUM COMPANY OF AMERICA, NEW KENSINGTON, PENNSYLVANIA

What determined the composition of the earth?

Why is its composition so uniform? Is it the result of chance or natural law?

You will find Dr. Foster's answer to these questions not only interesting and informative, but also based on sound scientific evidence.

With the complexities of modern living, we accept as common-place the earth on which we live and the processes that resulted in its formation. It seems natural that we should walk on sand and clay, climb a mountain of rock, and have an abundance of air to breathe. These things do not change anywhere on the surface of our globe. We would be startled indeed to stumble onto a chlorine well in Texas, a geyser of molten sodium in Yellowstone Park or a cache of metallic aluminum in Arkansas.

The accessible part of the earth appears to be very passive. It is free of violent action, and, in a chemical sense, equilibrated. It appears that this part of the earth is in its minimum energy state, and that all spontaneous reactions of any consequence took place a very long time ago. Occasional volcanic activity serves to remind us, however, that this passivity is probably limited to the crust of the earth, and that reactions of great violence and tremendous energy change are still occurring in the interior.

What determined the composition of the earth? Why is it so uniform everywhere we go? Did it result from chance or natural law? To answer these questions, we must go back several billion years and speculate on the conditions that prevailed during the formation of our earth and the universe.

There are several theories to explain the formation of the universe, and the distribution and abundance of the chemical elements. These differ in many details, but all agree generally that the multitude of chemical elements resulted from the processes of neutron capture and beta decay on initially small, primordial nuclei. According to one theory, the precursor of our universe was a tremendously large and hot gas of neutrons. Neutrons have a very short half life of about 12 minutes, after which they decay into protons and ordinary electrons. Consequently, a few minutes after the start of the universe there were present very large numbers of nutrons, protons and electrons—the fundamental particles of matter.

Initially, the kinetic energy was so great, because of the very high temperature, that nuclear binding forces were not operative, and the fundamental particles moved essentially independent of each other. As the mass rapidly cooled, however, these forces came into play, and the protons and neutrons began to assemble themselves into little clumps or aggregates of various proportions. These are recognized as the nuclei of the light elements. By the capture of more neutrons and protons, or of neutrons alone followed by beta decay, these small elements grew to form the myriad of combinations that we know as the isotopes of the chemical elements.

It would be easy to let the matter rest here and accept the distribution of the chemical elements as we find it. Before we can do this, however, we must explain or rationalize one serious inconsistency. If we could repeat this process of the formation of the elements in the laboratory, we could come out with an entirely different distribution. Some combinations of protons and neutrons are much more stable than other combinations. The lightest and the heaviest elements have lower stability than the elements of intermediate mass. Iron and the adjacent elements, manganese, cobalt and nickel, have the highest stability. All other elements must be considered to be in a metastable state with respect to them. Therefore, if equilibrium conditions could be maintained during our laboratory experiment, these few elements would form the greater part of the product.

Table I gives the actual abundance of the more common elements essentially as reported by Suess and Urey[1]. This shows that there is indeed a very large amount of iron. There are, however, equal or greater amounts of other elements; hydrogen, particularly, is present to the extent of several orders of magnitude more than all of the metallic elements combined. We must conclude then that the universe did not form under equilibrium conditions. Rather, it was "quenched" very rapidly from the high temperature, through the region where transmutation and readjustment of the nuclei could occur, to the temperature where the instability was "frozen in" in the majority of chemical elements. It is easy to account for the great preponderance of hydrogen according to this scheme because the hydrogen nucleus is simply a proton or the decay product of a single, isolated neutron. The chance of the neutron colliding with a number of other particles to form a large element was small compared to the chance of decaying into hydrogen. The great abundance of helium can also be explained by nuclear considerations.

A study of the universe shows a distribution of chemical elements not too far different from that predicted by the frozen instability theory. There is a great deal of iron as expected. Our earth presumably consists of a massive ball of iron or iron-nickel alloy with only a relatively thin crust of the other elements on

the outside. It is known that the metallic meteorites that fall into our atmosphere from outer space are largely iron, and iron is detected in the stellar bodies. Again in agreement with theory, the universe, taken as a whole, is essentially all hydrogen, on a percentage basis. Though there are appreciable amounts of hydrogen on earth in the waters of our oceans, by far the major part is contained in the active stars and as the intergalactic dust between them.

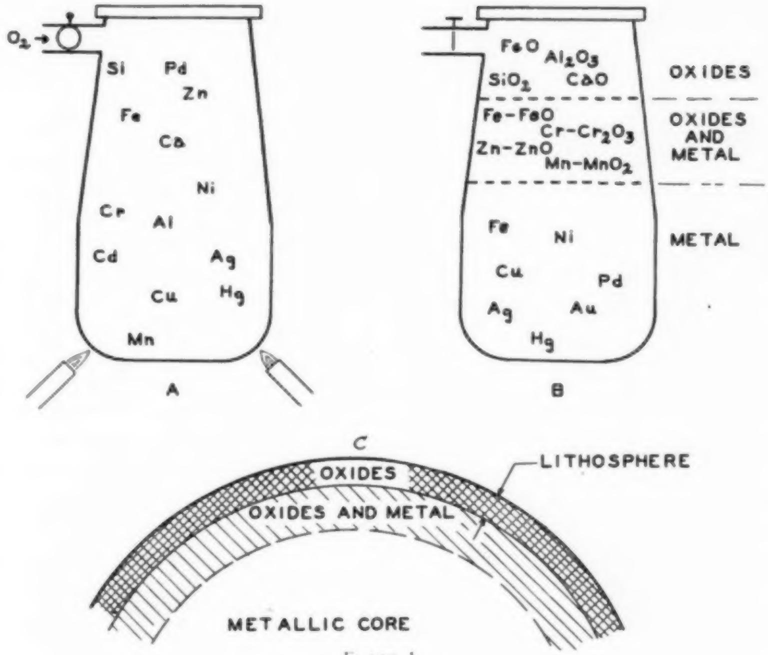

FIGURE 1

Consider man's immediate environment, the surface of the earth, for it is here (by definition) that the "common" elements are found. In TABLE II, the major elements of the earth's crust are listed in order of decreasing abundance[2]. On comparing TABLE II with TABLE I, reversals and trends are immediately evident indicating that the distribution of elements on the earth's crust is essentially independent of the distribution on a cosmic scale. The greatest inconsistency, of course, is the comparative absence of hydrogen and helium. This difficulty can be disposed of readily, since hydrogen and helium and most hydrogen compounds are light and volatile, and could easily have been expelled from our earth and atmosphere during the early stages of its formation. However, volatility does not account for the anomalous distribution of such elements as aluminum, silicon, calcium and a few others that compose the greater part of the accessible part of the earth.

TABLE I

RELATIVE ABUNDANCE OF THE MORE COMMON ELEMENTS IN THE UNIVERSE (SILICON = 1)

Element	*Abundance*	*Element*	*Abundance*
H	40,000	Ti	.0024
He	3,000	Co	.0018
O	21.5	Zn	.00049
C	3.5	V	.00022
Si	1	Cu	.00021
Mg	.91	Li	.0001
Fe	.6	Zr	.000055
Al	.095	B	.000024
Ca	.049	Pt	.0000016
Na	.044	Cd	.00000089
Ni	.027	Pd	.00000067
Cl	.0088	Ag	.00000026
Cr	.0078	Au	.00000014
Mn	.0069		
K	.0032		

To find an explanation for the distribution of these elements, the conditions that prevailed during the formation and solidification of our earth, rather than the universe as a whole, must be considered. An experiment can be devised to try to duplicate these conditions. This must be a hypothetical experiment, however, because of the lack in time, temperature and materials of construction to duplicate these conditions in fact. With that in mind,

TABLE II

COMPOSITION OF THE EARTH'S CRUST

Element	*Weight Per Cent*
O	46.59
Si	27.72
Al	8.13
Fe	5.01
Ca	3.63
Na	2.85
K	2.60
Mg	2.09
Ti	.63
H	.13
Mn	.10
Cl	.048
Cr	.037
C	.032
Zr	.026
Ni	.020
V	.017
Others	.34

imagine a furnace, shown in Figure 1A, which contains the greater part of the metallic elements that are present in the earth. This furnace is heated to a very high temperature—perhaps 10,000°C—then oxygen is admitted in proportions indicated by TABLE II. After

equilibrium is established, the heaters are turned off, the oxygen inlet is closed, and the furnace is allowed to cool very slowly. At 10,000° very little will happen, since this is above the decomposition temperature of most of the possible chemical compounds. On cooling completely in an excess of oxygen, all the metals shown here, with the possible exception of gold and platinum, would be converted into their oxides. Since there is a deficiency of oxygen, however, there will be a proportioning of this element along the metals. This distribution will be determined by the relative stability of the various oxides. The free energy of formation of the oxides is a measure of this stability. TABLE III gives the free energy of formation of the more common oxides shown in order of decreasing stability[3]. Arranged in this way, any metal high on the list will take

TABLE III
STANDARD HEAT OF FORMATION OF METAL OXIDES

Oxide	$-\triangle F$ *(per mole of oxygen)*	
CaO	303	
MgO	294	
Al_2O_3	260	
ZrO_2	258	
V_2O_3	220	
TiO_2	218	
SiO_2	202	
Na_2O	200	(4NaCl = 392)
Cr_2O_3	182	
K_2O	172	(4KCl = 416)
ZnO	167	
H_2O	136	(liq.)
CdO	130	
FeO	128	
MnO_2	123	
NiO	116	
CoO	115	
CuO	77	
PdO	42	
HgO	40	
Ag_2O	14	
Au_2O_3	−8 (?)	
PtO	-- (?)	

oxygen away from any oxide lying below it. Thus, metallic copper will take oxygen away from only palladium, mercury, silver and gold; whereas, metallic calcium will take oxygen away from all the other metal oxides.

Now, as a general rule, the oxide of a metal is less dense than the metal itself. Therefore, as shown in Figure 1B, the metals with high oxygen affinity separate to the top of the furnace to form a layer of non-metallic slag, and the metals in the free state, with the low oxygen affinity, sink to the bottom under the influence of gravity. In between, there will perhaps be a zone of mixed metals and oxides of the metals that are of intermediate stability.

Finally, if this furnace were enlarged to form a spherical ball 8000 miles in diameter, as in Figure 1C, it would resemble our earth, with a thin, non-metallic crust—the lithosphere—perhaps 10 miles thick overlaying a region of mixed metal and oxides, and a dense metallic core consisting principally of iron with unknown—possibly large—proportions of the rare metals.

There are one or two exceptions to this general scheme. Large amounts of sodium and potassium in the earth's crust are present as the chlorides rather than the oxides. Chlorides of such elements as silicon and aluminum, on the other hand, are essentially absent. This interesting situation derives from the fact that the chlorides of these alkali metals are considerably more stable than their respective oxides. These elements will take up the greater part of the chlorine in TABLE II and become incorporated in the non-metallic layer.

Only the primary compounds of the metals are shown in Figure 1. The secondary compounds, such as the mixed oxides and hydrates, will not form until a later time. As a general rule, an exothermic reaction will not occur at temperatures in the vicinity of the decomposition temperature of the product. Thus, at the start of the universe, the primary particles could not assemble into larger nuclei until the temperature decreased to the point—perhaps many million degrees—where the nuclear binding forces were in excess of the kinetic energy of the system. Electrons became attached to these nuclei only when the temperature fell below the total ionization potential of the elements—perhaps many thousand degrees. Chemical reactions, such as those to form oxides in our furnace, began only when the temperature dropped below that which would rupture the chemical bond—perhaps below 10,000°C. Finally, mixed oxides and other compounds such as the clays, spinels, and minerals of all sorts began to form only at temperatures where the loose binding in these types of compounds was stable. This is in the range of a few hundred to a few thousand degrees centigrade. These last types of reactions constitute the usual phase diagrams of mineral systems. Finally, the hydration of the minerals is a process that cannot occur much above the ambient temperature of the earth as we know it today.

Thus, we see that what appeared on superficial examination to be chaotic disorder in the universe appears to be the greatest exemplification of order and system. ●

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What Does Industry Expect of Technically Trained Graduates?

• By R. H. Scheldt, M.S., *(Georgia Institute of Technology)*
PERSONNEL DIVISION, EMPLOYEE RELATIONS DEPARTMENT, E. I. du PONT de NEMOURS & COMPANY, INC., WILMINGTON 98, DELAWARE

This article contains the answers to many questions asked by students. The author, an experienced personnel man, discusses the qualities sought in applicants for positions in scientific fields.

We believe that you will find Mr. Scheldt's summary of the general attributes necessary for productivity in technical fields most useful in your work of counseling and guiding students.

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The problem of educating well qualified personnel in the fields of science and engineering is a particularly acute one. Any reader will note frequent articles which point out the serious task which confronts education and industry. The limiting factor for many industrial expansion programs eventually may be the availability of scientists and engineers.

The natural reaction when confronted with such an important task might well be to think of overcoming it by producing large "quantities" of technically trained individuals. However, all of us will accept the fact that one well trained scientist or engineer can contribute much more than a number of mediocre ones. Hence, the better solution to the problem seems to be that of concentrating on "quality" rather than on pure numbers.

What types of jobs must the technical graduate perform successfully in industry? Basically, the assignments in industry are in research, development, production, and sales. Since we have previously concluded that the "quality" of the individual is very important, it appears appropriate to explore those "qualities" which are felt to be necessary for successful job performance in each type of activity.

Research

Basic research work in all fields of science and engineering are conducted in industry. However, for the purpose of illustration, let us imagine that we are in a chemical research laboratory observing a chemist at work. On this particular day his efforts in the field of chemistry are bearing fruit for he has just come upon a reaction that is destined to produce a new material. This material is analyzed, its physical properties are evaluated, and it appears that it has commercial application. Before going further, let us see what was necessary in order for our chemist to progress this far.

First, the individual is well educated in chemistry, mathematics, physics, and related subjects—perhaps to the Ph.D. level. He was a good student, who has always been interested in the "why" of things. He has prepared himself for this day in his life through intensive study which has developed his ability to attack problems in a systematic, logical manner by applying fundamentals. He possesses a thorough grounding in literature survey work which allows him to search the technical literature available for background information pertaining to his problem. He is a teamworker, because most industrial research programs require the coordinated effort of many individuals.

Development

Since the material discovered by our chemist has possible commercial application, it must be thoroughly explored by group effort. This group is perhaps composed of chemists, and chemical, mechanical, and electrical engineers, with Bachelor's, Master's, and Doctor's degrees. They must answer questions regarding commercial applications and cost of manufacture of the material as compared with competitive products, quality requirements, return-on-investment, and many more. Eventually, enough basic data will be gathered for the development program to proceed further.

Then our task force will design a pilot-unit process, which duplicates the reaction achieved in the chemist's laboratory, in order to further evaluate the product and to gain basic data which will be required in order to scale up to a commercial-size production plant. These individuals, like the chemist previously mentioned, must be technically proficient. Since they are working on the fringes of the unknown, they necessarily must possess imagination, thorough grounding in the scientific approach, perseverence, and the drive necessary to see their project through to its completion.

By coordinated effort, they will design and supervise the construction of equipment, start the process, evaluate and refine it a number of times. They no doubt will encounter many setbacks. However, eventually they will present their management with their findings and conclusions. This necessarily requires thorough ability to correctly use the English language both in written and verbal form, because ideas and findings must be presented in clear and meaningful form in order to gain acceptance.

Now let us assume that, after careful evaluation of this information, management gives approval for the construction of a full-scale plant involving a multimillion dollar investment. It is evident that a tremendous responsibility rests on the technical man to furnish honest and objective information, for if the information is erroneous, a great loss of creative capital could result.

Once the decision to build a plant is made, then full-scale equipment is designed and constructed. Development work does not cease here; however, it will continue to take place on the plant site. The process of today can always be improved tomorrow. Such improvement may result in better yields, improved quality, lower cost of manufacture, and increased safety. Hence, a healthy state of dissatisfaction with things as they are is a powerful attribute for the technical man to possess. All of us know that when an organization becomes complacent with its position, it will be rapidly overcome by competition. The individual who is constantly striving to improve, not only himself but his company's operation, is indeed very valuable.

Production

Once the plant is built the production man takes over. Basically, it is his job to supervise his people in order that the materials at hand are processed through the process equipment according to operating standards. The ultimate goal of this effort is the production of a quality product, at the lowest possible cost, while maintaining good personnel relations and a clean and safe work environment.

This sort of assignment is indeed a challenge to the technical man. Since he is not engaged in fundamental scientific endeavor, advanced degree training is not imperative, but he does need a good technical background. Almost daily, he will have to make decisions concerning an extremely complex technical operation which can mean thousands of dollars of loss if the wrong decision is made. However, of perhaps greater importance is his ability to deal effectively with people and their problems. He must possess those characteristics of leadership which command respect, cooperation, and maintain morale.

After the plant is built and operating, there is a tremendous job at hand since many complex pieces of mechanical and electrical equipment on the plant site must be maintained. In addition, such functions as power generation and distribution, design for additional plant facilities and improvements, and minor construction will provide a continuous challenge to the engineers on the plant.

Sales

Once the product is manufactured, it must be sold. The customer must know what the product will do and how its use will benefit him. This is the basic responsibility of the technical salesman.

Since many products used in industry are highly technical in nature, it is necessary that the salesman who deals with such products be technically competent in order that he may explain to his customer the nature and various applications of his product. Equally important for sales is a good appearance and personality coupled with the enjoyment of contacting people, because the salesman must present his product in an appealing and convincing manner.

In addition, it is necessary to supply technical service to the customer after the sale has been made. The technical service representative assists the customer with processing problems, answers and investigates complaints, and keeps him advised of new developments. Also, he serves as a liaison man between the customer, the plant which produces the product, and the research laboratory, in order that mutual problems concerning quality, cost, process ability, etc., can be worked out efficiently.

Summary

The above discussion has given a quick panoramic view of the activities in which technical men engage and the general attributes necessary for one to be productive in such activities. The key points mentioned may be summarized as follows:

1. The individual should have a firm grasp of the fundamental concepts concerning his chosen field.
2. The attack of problems in a systematic, logical manner by applying fundamentals is highly desirable.
3. The individual should be able to adapt himself and his talents to those of an integrated group.
4. The ability to express oneself both orally and in written form is necessary in order to present ideas properly.
5. The individual should constantly strive to improve himself and his company's operation.
6. Perseverance and drive are necessary in order to see things to their completion.
7. The ability to get along with others is of extreme importance. *Many individuals with keen intellects fail to really contribute because of personal rather than professional shortcomings.*

Additional Comments

We in industry realize our responsibility to continue with the training and development of the individual after he has completed his academic training. Large sums of money are spent annually to further the individual's technical and personal development by providing him with the latest available training material. In addition, he is given close and constructive supervision in order that he can realize his maximum potential.

You, as high school teachers of science and mathematics, deserve a great deal of credit for the good job you have done in the past with respect to training and preparing young people for technical careers. However, a great job lies before all of us. You can further assist this effort by encouraging young people with technical aptitudes to pursue a very fascinating and rewarding career in science and engineering. In addition, you can continuously strive to improve the technical content and quality of the courses you teach, and of equal importance, present this course material in such a manner that it will serve as a training ground to develop many of the qualities previously mentioned. ●

The Science Seminar, An Integrating Tool

• **By Sister Denise Eby, M.S.**
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Specialization has even affected our educational system. College courses tend to be directed to the preparation of specialists.

An interdepartmental seminar is an effective means of integrating the student's training in the sciences and his training in the liberal arts.

The liberally educated man is he who can interpret the findings of various fields. However specialized his education, he must have an understanding and appreciation of the interrelationships of the sciences, not only with each other, but also with economic and Christian social living. Thus the second half of the twentieth century finds educators confronted with the problem of teaching man to adjust to an environment in which science and technology play a significant role.

The solution of this problem represents an objective toward which education should direct every possible resource. The natural sciences have advanced to a point where a high degree of integration is necessary for further research in any one field. If students specializing in these sciences must expand their views to include an understanding of such interrelationships, then the liberal arts college must accept its share of the responsibility to facilitate the achievement of this goal. This, in itself, is no small undertaking, for present day college science courses tend to be narrowly organized for the benefit of the specialist. Therefore, many teachers find themselves unequipped to cope with the problem single-handed.

Many and varied methods have been devised and used successfully by colleges in attacking this problem. The Science Seminar at St. Joseph College, planned and executed jointly by faculty and science majors, is one such method. Keenly aware of the inadequacy of any single person to effect the desired end, the Division of Natural Sciences realized the necessity of some concrete means of working as a group toward the desired goal.

At the time of this writing, the Science Seminar may well be considered an effective integrating tool at St. Joseph College. Literally, it has evolved from very primitive beginnings to its present status. The idea was conceived by the Head of the Division of Natural Sciences when he received a gratifying response from science majors whom he invited to attend a regional meeting of the American Chemical Society. Several weeks later an extra-curricular talk on astronomy and a demonstration of a planetarium by one of the faculty met with the same enthusiastic response. The next faculty meeting of the Division of Natural Sciences effected plans for an organization which would devote itself to giving students an insight into the wealth of knowledge in the various scientific fields, and to making them conscious of the interdependence of these fields in the accumulation and application of this knowledge.

At present the Science Seminar is an informal organization, having two student publicity agents and a scribe. Meetings are held bi-weekly at an hour when all science majors are free to attend. Although the Seminar is a non-credit course, the programs thus far have been of such interest that they are well attended, not only by science majors, but also by many other students and members of the faculty. Topics selected from the fields of science and philosophy are presented in a manner to encourage group discussion, and whenever possible a specialist in the designated field is invited to act as a resource person.

An outline of the Seminar sessions for the semester, February 1956 to May 1956, is presented here as a typical series of programs. Topics are selected by faculty and students of the Division, and usually grow out of special interests or perceived needs of the majority.

SCIENCE SEMINAR SESSIONS
February 1956 - May 1956

I. Astronomy
   A. Fundamentals of Astronomy
   B. Demonstration of a Planetarium

II. Biology
   A. Human Blood
      1. Composition and properties of blood
      2. Blood counts
      3. Blood groups and typing
      4. Rh factor
   B. Demonstrations
      1. Blood counts
      2. Blood typing
      3. Rh typing

III. Philosophy and Science

IV. Evolution
   A. Theistic Evolution—Biological Aspects

V. Evolution
   A. Evolution—Theological Aspects

VI. Geology
   A. Famous Gems
   B. Geologic Formations
      (Kodachrome slide illustrations)

VII. Philosophy and Science
   (A sequel to III)

(Continued on Page 146)

Correlation of Art with High School Biology

• By Sister M. Maurice, R.S.M., M.S., *(Villanova University)*
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Drawings made from actual specimens, serve to develop the biology student's ability to observe. Do not let your conviction that only the specially gifted can draw, allow you to deprive your students of this excellent teaching aid. Take your pencil and paper, and let Sister Maurice show you that you can not only draw but also teach others to draw.

This article is from a paper presented by Sister M. Maurice at the spring meeting of the Pennsylvania Round Table of Science, at St. Vincent's College, April 28, 1956.

Many teachers of high school biology are confronted with the double task of giving instruction in drawing as well as teaching the fundamentals of biology. To some, this dual responsibility presents an almost impassable barrier because they think the ability to draw belongs to a chosen few, gifted with inherent artistic ability. It is true that a comparative few, so gifted, do attain honors as known artists; but it is equally true that any student with normal intelligence can be taught to draw.

In our biology drawing classes, we must consider two groups of students; the talented and the untalented. The talented child finds little difficulty in drawing the specimens he studies. The untrained or untalented student is at a loss; he is unaware of his potentialities as an artist, as he is unaware of the fact that drawing is merely a complicated form of writing and can be taught to the uninitiated. Anyone who can observe direction of lines and their relationship to each other can, with a little conscious practice, make a representation of facts as they are observed. Science requires a record of what one sees and the way it looks.

I would like to present to teachers a simplified, mechanical method whereby the power of reproducing pictorially the results of scientific observations is placed within the scope of every student of high school level. There is no incongruity in learning the facts of biology and at the same time learning to draw.

It is not the purpose of this article to cover the entire plant and animal kingdoms, hence only a few forms will be represented.

All animal and plant forms can be constructed primarily upon the circle, the oval, the cylinder, the triangle, and some modification of these geometric figures (Fig. 1). If a student can be made to see the geometric solids as fundamental basic forms for objects he is to draw he has taken the first step toward producing a good figure. Work should proceed from the whole to the part; from the big to the little. All figures should be drawn from the specimen studied—reproducing copied forms defeats the purpose of drawing as an integral part of biology and cheats students of the discipline that the study of science confers.

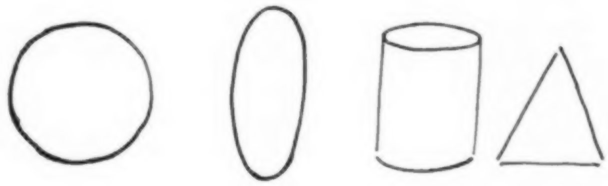

FIGURE 1

Take your pencil, biology teacher, and try these forms the easy way. A crayfish, reduced to its most simple forms, yields ovals and trapezoids. Dorsally, the chitinous carapace resembles an oval, the short axis of which is about one-half the length of the long axis. The abdominal region may be looked upon as an overlapping trapezoid to which is attached another inverted trapezoidal figure to form the tail-like uropod. The chelipeds are also oval in structure (Fig. 2).

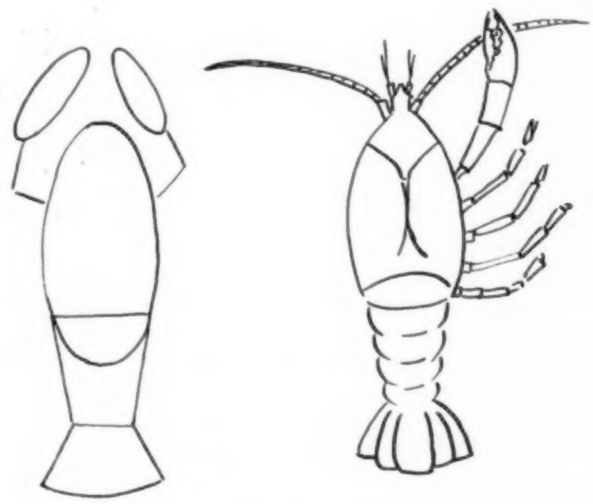

FIGURE 2

The three body parts characteristic of insects are based again on the oval and trapezoid. We begin with the thorax by drawing a trapezoid with the wide base at the top. Place an oval slightly in front and we have the head. Note the slant of the long axis. The abdomen is another longer oval. Now we have the foundation and we are ready to add details (Fig. 3). Two vertical

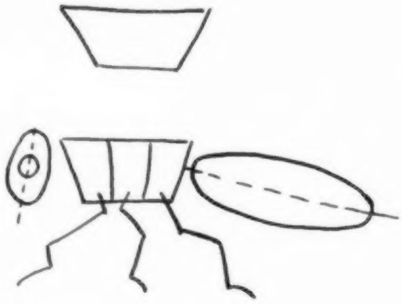

FIGURE 3

lines dividing the thorax into three segments indicate the position of the legs. Sketch in the leg lines. Figure 4 shows the completed animal; only the wings are lacking. These are basically oval or triangular and attached to the body at the thoracic portion, and are typical for each order. Figure 5 illustrates some of the more basic forms.

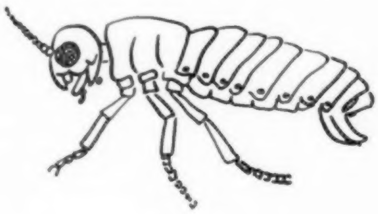

FIGURE 4

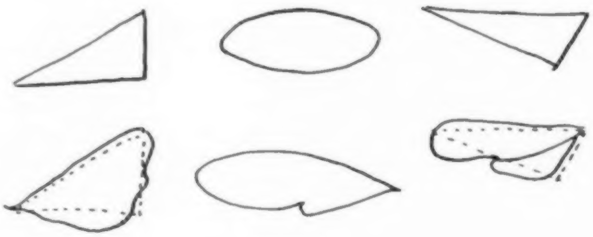

FIGURE 5

Externally a frog presents little difficulty because it can be formed upon an oval, and with the addition of a few angular lines is complete except for the hind legs (Fig. 6). These are made with what is often called the "french curve" (Fig. 7). The short axis indicates the position of the hip bones, and proper slant of the long axis produces the characteristic squatting position. Figure 8 shows the completed sketch.

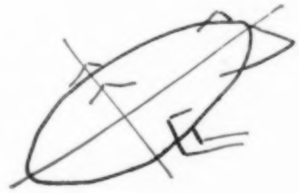

FIGURE 6

FIGURE 7

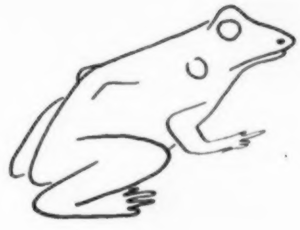

FIGURE 8

For study of the internal anatomy of the frog an outline sketch is derived from an oval and a partially flattened triangle (Fig. 9). Try it.

FIGURE 9

Nature study classes sometimes make a study of birds. Here is a very simple way to draw one. First, draw a semi-circle. With two dots divide the diameter into three equal parts. In the first part draw another smaller semi-circle; that's the head (Fig. 10). Add an eye and a beak. Extend the back an equal distance and add a ruffled line, and the bird has a tail. The wings begin under the head and can be drawn as a big C. The second dot on the diameter offers a clue for proper placement of the nearer leg. The far leg appears shorter and is placed slightly in front. Add a minus sign to each leg, then an arrow head and for practical purposes, our bird has all its parts (Fig. 11).

(Continued on Page 150)

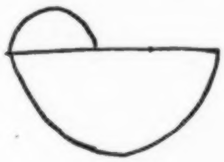

FIGURE 10

Analyzing for the Products of a Nuclear Reaction

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This article should be studied, not read.

Teachers of physics and chemistry will find this non-mathematical description of the methods and tools used in the identification of the products of a nuclear reaction highly informative.

When thermal neutrons, high energy electrons, gamma rays, mesons, protons, deuterons, or heavier particles strike a substance, some of the atoms in the target will transmute to another atom. The product nucleus may differ from the original in atomic weight, atomic number, or in both quantities. Usually more than one product results from a given reaction, the others being among those "elementary particles" mentioned above as possibile projectiles, electrons excluded.

Merely out of curiosity, we might wish to learn what these products are and which are produced in largest amounts. A more important reason to identify and determine the respective yields of the several products is the help this information gives us in understanding nuclear structure. Such understanding is essential if we are to make the fullest use of nuclear energy. The yield of a particular nuclide[1] is expressed as a cross section. This is an area unit, the idea being that the reaction occurs only when the projectile passes through a definite area of the nucleus. It can more correctly be pictured as a measure of the relative rate of a particular reaction. For example, when vanadium-51 is bombarded with 240-Mev protons, the yield of Ca^{45} is 0.33 millibarns (equal to 0.33×10^{-27} cm^2 since one barn $= 10^{-24}$ cm^2), while that of Ca^{47} is 0.011 millibarns. In other words, Ca^{45} is produced thirty times as fast as Ca^{47}.

The cross sectional area of a V^{51} nucleus is estimated to be about 850 millibarns. If the cross sections for all the possible reactions produced in vanadium by 240-Mev protons were known and summed, it is believed they would equal the actual geometric cross section.

The cross section, σ, is actually defined by the expression $N = \sigma I n_t$. N is the number of reactions produced per second per square centimeter of target area by a beam of I particles incident per second on a square centimeter of target. The number of target nuclei in this square centimeter is n_t. The product σI can be considered as the fraction of available nuclei that undergo a specific reaction, i.e. the probability that one nucleus will so react. I is a measure of the number of chances available while σ, constant for a given process, is the probability with which the chance is accepted.

Normally irradiation is carried out by placing the target inside a reactor (neutron irradiation) or inside an accelerator such as a cyclotron (charged particle irradiation). In some cases (mesons, photons) the projectile beam is brought out of the accelerator. The target itself is, when possible, a pure, mono-isotopic element. Often, though, a simple salt of the naturally occurring element is used.

Now let us consider the methods used to identify the transmutation products. These products can be grouped into three classes: (1) radioactive nuclides of reasonable (i.e. about fifteen minutes to a few years) half-lives, (2) stable nuclides and extremely short-lived and long-lived radioactive nuclides, and (3) small particles (protons, deuterons, etc.) and photons. The distinguishing feature in this division is the method of detection.

Radioactive nuclides of convenient half-life are most easily identified by chemically separating the elements present after irradiation and then determining the decay characteristics present in each elemental fraction.

The active target is dissolved in a convenient solvent, containing, if at all possible, a few milligrams (called carriers) of each element expected to be present. Each of these elements is then separated, in as pure a state as possible, from all the other added carriers and the target. It is assumed that the radioactive isotopes of an element behave chemically as do the stables and so are carried by the macroscopic amount of added material.

The first precaution that must be observed is to assure that all the radioactive material gets into the same chemical state as the carrier. For example, if iron is an expected product it may exist after solution in the ferrous or the ferric state. The carrier should then be passed through each oxidation state before any separation is undertaken. In the case of iodine, carriers for each oxidation state should be added; merely passing from periodate to iodide might not pick up trace quantities in an intermediate state. It is not safe to carry out these scavenging operations before addition of a carrier. The chemistry of a small number of atoms (10^6 to 10^{10}, typically) is not necessarily that of normal quantities. In fact, such a small quantity might be completely lost by adsorption on the walls of the vessel used to dissolve the target.

The ability of stables to quantitatively carry the radio-active nuclides provides one important aid to the analyst. By determining the fraction of added carrier

[1] The word nuclide was coined by T. P. Kohman who defined it as "a species of atom characterized by the constitution of its nucleus, in particular by the number of protons and neutrons in its nucleus." It should not be confused with the word isotope, which implies species of the same element differing only in atomic weight.

finally isolated free of contaminating activities, he knows the fraction of reaction-produced radioactivity recovered. Rapid separations are thus possible, and a high degree of radioactive purity can be attained by use of non-quantitative chemistry.

The most used separation method is brute force semi-micro qualitative precipitation and centrifugation. The two problems in this technique are (1) occlusion of radioactive impurities and (2) incomplete precipitation. Occlusion is overcome by dissolving the separated precipitate and reprecipitating, having first added a "hold-back" carrier to keep the unwanted radioactive nuclides in solution. Since the actual weight of occluded material is usually small, satisfactory results will be attained if the great majority of impurity atoms carried down are stable. Incomplete precipitation is only important if the supernatant solution contains the desired constituent. The solution can be "scavenged" by adding more precipitable carrier and repeating the precipitation a few times.

Solvent extraction, being quick and clean cut, is often used. Much development work on the subject has been done in radiochemistry laboratories over the past fifteen years. With proper control of pH and use of chelating agents, most any element can now be extracted from aqueous to non-aqueous solution. Here hold-back carriers may or may not be necessary, but the extraction is usually not quantitative.

Ion exchange separation techniques have been used primarily with the rare earths and trans-uranics, although they can be made to give good results with most any system. The method involves selective adsorption and/or desorption of different ions on a solid material packed in a column. Both fast and clean separations can be made.

Distillation, electrodeposition, and chemical displacement are used in special cases. An example of the latter is the plating of bismuth on nickel powder. If distillation is possible, the corresponding difficulty of loss of volatile material from the target before solution or before complete mixing with carrier is present. Both of these possibilities require careful handling, the outcome depending greatly on the experimenter and his technique.

From the point of view of actual choice of chemistry, there are three important considerations: (1) normally the products are adjacent in the periodic table, (2) the target is probably present in large quantity (maybe 200 mgs. or more) compared to about ten milligrams of each carrier, and (3) the final chemical yield should be measurable.

The first two points mean that the separations are not commonly known to the chemist (as are the family separations used in the ordinary "qual" scheme) and must be worked out in each case. No element can be ignored because its chemistry is complex. The large amount of target material usually demands either removal by a method other than precipitation, or retention in solution while the products are precipitated.

Chemical yield is most easily determined if the final precipitate is in an easily weighable form. Although the total amount will be small, and the error thus large, an error of 10 per cent in this quantity can usually be tolerated. If weighing is not feasible, the precipitate can be redissolved after "counting" is complete, and the element determined colorimetrically.

Counting implies the measurement of the decay rate of an elemental fraction. Actually three quantities are desired: (1) the nature of the radiation, i.e. is it a positron, electron, alpha particle, or photon, (2) the energy distribution of each, and (3) the half-life (time required for the decay rate to drop in half). Establishing the nature of the radiations is relatively simple. If they seem to be efficiently counted by a Geiger-Müller tube and are affected by a magnetic field, they are positrons or electrons. The direction in which the field bends the particles shows their sign. If a scintillation counter registers many more disintegrations per minute than does the Geiger counter, photons are present. They may be X-rays or gamma rays. Alpha particles will not normally be observed without special counters. Because of their short range in matter, they require very thin counter windows. Often alpha sources are placed within the counting chamber itself. A good measure of the energy distribution requires more elaborate equipment. Beta particles (positrons or negatrons) are usually bent by a magnetic field into a detector, e.g. a Geiger tube. The field strength is proportional to the energy of the particles being bent through a given angle. A counting rate dependent on magnetic field and so on beta energy is obtained. The resulting distribution (beta spectrum) is distinctive for each nuclide. Also distinctive is the maximum beta particle energy coming from a nuclide. This can be determined approximately by measuring the radiation's maximum penetration through a substance like aluminum. The procedure is to count the sample through increasing absorber thickness until all particles are absorbed. Absorbers are relatively cheap, but a spectrometer has the advantage of separating positive from negative particles and both from photons, as well as being more accurate. But it usually requires a more intense source, which may not be available.

Electrons are also emitted by the process known as "internal conversion", in which an electron is ejected from an atomic orbital. This occurs in certain cases when the nucleus gives up a definite amount of energy and gamma emission might have been expected. These electrons are monoenergetic, and are distinguishable by their line spectra.

The energies of alphas, gammas, and X-rays are most accurately determined by pulse height spectrometers. These use either crystal detectors or gas-filled tubes. In the first case, the energy of the impinging radiation is converted into a number of visible light photons, the number being proportional to the original energy. These photons are converted electronically into voltage pulses, whose magnitude depends on the number of photons and thus on the original radiation energy. In the gas tube, the amount of ionization produced by

the radiation is proportional to the energy. This ionization is amplified, the resulting pulse again being proportional to the original energy. In both cases a spectrum, i.e. the fraction of particles having a specific energy given as a function of energy, is determined. Alphas, gammas, and X-rays are monoenergetic, and they give distinctive line spectra. These energies can also be determined by observing their absorption in aluminum, lead, and aluminum or beryllium, respectively. But the results are not nearly as accurate as spectrometer measurements.

Half-lives are best determined by following the rate of decay with a suitable counter—Geiger or gas proportional for betas, scintillation for gammas, scintillation or gas proportional for alphas and X-rays. If more than one activity exists in a given sample, the mixture is most easily resolved by plotting the logarithm of the counting rate versus the time of measurement. Eventually the straight line behavior, indicative of a single nuclide, will appear. This will be due to the longest lived nuclide, the rest having decayed away. Back-extrapolation and subtraction of this line will give the original data less the contribution from the longest-lived activity. A new straight line, due to the second longest activity, should appear. The subtractions, etc., are repeated until all the remaining points fall on a straight line. The slopes of the several lines give the half-lives of each isotope present. Occasionally the mixture is too complex. Then more elaborate methods, such as counting through absorbers, which will remove weaker components, or with spectrometers, are necessary to separate similar isotopes.

The determination of atomic number by chemical means coupled with characterization of the radiations almost always makes possible identification of the nuclide, provided it has been previously observed and identified.

If the nuclide is completely new, or not well known, the experimental problem is to prove its mass. The atomic number will have been determined chemically. The mass determination can be done mass spectrometrically. More likely it will be based on consideration of the means by which the nuclide is made and how its radiation characteristics compare with those of the known isotopes of the element. In other words, it is fit into the scheme, much as Mendeleef placed tellurium and iodine in his periodic table. Occasionally the problem is simplified because the nuclide decays to a known radioactive daughter. Then consideration of the radiations emitted during decay gives the needed correction of the daughter's mass.

The counting data obtained in the half-life determination can be used to calculate the yield of the nuclide. Correction of any counting rate value for decay since the end of the bombardment gives the unmeasured counting rate at that instant. This value must only be divided by the counting efficiency, chemical yield, and the fraction of nuclides that decay per minute in order to arrive at the number of nuclides present. This will be somewhat less than the total number produced, because decay is going on during irradiation. An accurate correction for this effect can also be made. Thus the total yield of the particular nuclide is calculable.

The largest source of error is the counting efficiency. Most commonly, the yields are based on beta counts, taken either with a Geiger counter or a proportional counter. Corrections must be made for back-scattering, scattering off the walls of the sample chamber, self-scattering and self-absorption by the sample bulk, air and window absorption, air scattering, geometry, and counter sensitivity.

Scattering of beta radiation off the sample support (backing) usually increases the counting rate about 25 per cent. Normally the sample chambers are constructed of Lucite, which does not appreciably scatter electrons. Housings made of metal can scatter a good percentage of the radiations into the counter. There will be a significant loss of particles due to absorption by the material between their source and the sensitive volume of the counter, i.e. by the sample material, by the air through which the betas pass, and by the counter window. Detailed consideration of the mechanics of electron scattering indicates that scattering within the sample tends to collimate the betas in the direction of the counter, thus tending to increase the observed counting rate. For want of a better answer, air scattering is usually considered negligible. Both Geiger and proportional counters are usually at least 98 per cent efficient in counting beta particles passing through their sensitive volume. The solid angle, origin at the sample, subtended by this sensitive volume is the geometry factor.

The several absorption corrections are strongly energy dependent and are the most serious problem. To avoid them, internal counters are often used. For example, C^{14} is best counted in the form of CO_2 injected directly into the counter where it mixes with the counting gas. The other general technique for C^{14} determination, precipitation as $BaCO_3$, is inherently inaccurate due to absorption and self-scattering.

Overall, the radiochemical analysis is usually accurate only to within a factor of two.

The other products of the nuclear reaction are not so easily determined. Stable and very long-lived nuclides are not yet determinable, although their yields have been estimated by extrapolating the patterns observed for the measurable radioactive products. Probably an improved mass spectrometer will some day make these measurements.

Rather short lived (one to ten minute half-life) material can be determined by performing rapid chemistry immediately after removal of the target from the cyclotron or reactor. Sometimes use of spectrometers to sort the several radiations permits observation of the individual activities without resort to chemical separations. In at least one case, a mass separation using the cyclotron's magnetic field immediately after bombardment has been applied to short-lived nuclides. Counting of the activity was still necessary; the mass

(Continued on Page 142)

The Story of Veterinary Medicine

• By Kenneth B. Haas, D.V.M., *and* J. Lavere Davidson, D.V.M.
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Here is an interesting history of a scientific field whose importance is underestimated by the general public.

The present demand for veterinarians is greater than ever before. They are needed, in ever greater numbers, to protect the health of the animals that feed and clothe us.

Disease was one of the earliest threats to prehistoric animal life. It was, and is still, one of the great tragedies of living things. The first manifestation of animal disease was the first call for a veterinarian.

Man found himself surrounded on every hand by predacious beasts, with himself as one of the prey. Having the gift to tame, man domesticated practically all the valuable species in use today within a relatively short period. He came to rely more and more on animals to supply his food, power, clothing, and transportation. Conceived of necessity and sympathy, animal-healing arts began to evolve. Man was able to grasp the concept that tribes and peoples having a well-developed animal husbandry were better off and had a more constant and better supply of food. Successful warriors were the good animal husbandrymen; superiority was with those countries wise in animal care. Egypt was one of these countries.

Egypt

Horses were extensively used in the Egyptian armies. Cattle were their wealth, camels and donkeys their freighters, oxen their field animals. Egypt was one of the first countries in which veterinary medicine was known to flourish.

By the time hieroglyphics recorded the story, animal-healing was already old. One of the earliest papyri yet discovered is the "Veterinary Papyrus" of Kahun, dated 2100-1788 B. C. Two diseases of cattle and one disease of dogs were described. Venesection, cold packs, and vegetable poultices were prescribed. This papyrus reveals early existence of the veterinary *art*. It supports the assertion that veterinary *art* is older than civilization itself.

Animal medicine in Egypt eventually stagnated, then retrogressed. A defective animal economy resulted which was finally destroyed by the fifth plague in 1451 B.C. (Exodus 9).

Babylonia

Contemporary with Egyptian culture was that in the fertile valley of the Tigris and Euphrates rivers. This was Babylonia, occupied in turn by the Sumerians, Akkadians, and Amorites. The people of Babylonia under Hammurabi (2285-2242 B. C.) thought highly of their veterinarians and expected reasonable professional competence from them. The Code of Hammurabi was the first veterinary practice act and fee schedule:

"224. If a doctor of oxen and asses has treated either ox or ass for a severe wound, and cured it, the owner of the ox or ass shall give to the doctor one-sixth of a shekel of silver for his fee."

"225. If he has treated an ox or an ass for a severe wound and caused it to die, he shall give the quarter of its price to the owner of the ox or ass."

In comparison to the fees prescribed for physicians of that day, the veterinarian's fee was small. This is the first recorded indication that a veterinarian's fee was related to the market value of the animal treated.

Greece

We find the cultures of three continents, Africa, Asia, and Europe, converging in Greece. Veterinary medicine reached great rational development there.

Hippocratic practices had their foundation in gentleness, ethics, physical examination, fresh air, sunshine, good food, and rest. Medicine was transported from empiricism to rationalism. Veterinary technics of the era reflected this rationalism.

Aristotle wrote extensively on veterinary subjects. He described 500 species of animals, concerned himself with the diseases of domestic animals, recognized swine anthrax, colic and tetanus of horses, and the transmission of rabies by means of a bite.

Records from as early as 500 B. C. indicate that there were public veterinarians in the employ of the state. This is probably the first recorded instance of active governmental participation in public health and veterinary medicine.

Rome

Rome conquered Greece and appropriated its culture. The transplantation attenuated the quality of veterinary technics. The Romans were not vitally interested in animal medicine *per se*, but took great interest in agriculture and animal breeding and feeding. They were advanced bromatologists.

Cato the Censor (233-148 B. C.) wrote on the advantages of using feeding racks and clean water in cattle feeding. The words "veterinary" and "veterinarian" first appear in his writings, as "veterinarius". It was synonomous with "mulomedicus," a mule physician.

Marcus Tarentius Varro (116-27 B. C.) wrote on the diseases of farm animals; Virgil (70 B. C.) considered animals in the third of his four Georgics; Columella (42 A. D.) refers to animal plagues and prescribes isolation of diseased animals; Pliny concocted numerous

imaginative animal fables; and Galen was the first to suggest that a food product of animal origin be subjected to inspection prior to being consumed by humans.

Arabia

It was largely due to the horse that the Moslems were able to found a great empire so quickly. The superiority of mounted troops helped them to cut the Roman Legions to pieces. Arabian veterinary medicine penetrated far beyond its national boundaries.

The Arabs discovered nitric acid and corrosive sublimate, introduced camphor, rhubarb, senna, and nux vomica, gave us the terms syrup, julep, alkali, and alcohol. Their veterinary medicine was a bright light at a time when European practices were floundering in quackery and rank farriery. They were fine horsemen and serious hippiatricians. They performed surgery, used styptics and ligatures; gave castor oil, mercurial diuretics, and calomel. The actual cautery was for a while their national panacea.

Arabian progress in veterinary medicine was eventually halted by the Islamic attitude, "If it be granted to the sick to recover, they will do so." The Arabian veterinarians began to wait rather than act.

Medieval Europe

From the time of Galen to the time of the great awakening, Europe was in the doldrums of the Middle Ages. Greek veterinary medicine had ceased to function. A "fact" was not valid unless backed by whimsical fable; investigations into animal anatomy and surgery were closed. Brutal farriery and deforming horseshoeing were the order of the day. Veterinary progress was negligible.

Alexander Neckam reworded the ancient theory that animals instinctively know the drugs that will cure them in time of sickness, for "educated by nature, it knows the virtues of herbs, although it has neither studied medicine at Salerno nor been drilled at the schools at Montpellier." The Anglo-Saxon Leech Books reiterated the chant: "The dogge when he is sick at the stomach knows the grass that will cure him."

Paradoxically, as Moslem culture began to decline, it was rediscovered by Europe in Greco-Roman guise. With the revival of learning in the 14th century, the *science* of veterinary medicine began to emerge. Animal parasitology was initiated; a pharmacopea was published in Florence in 1397; Carlo Ruini, a veterinarian, described in detail the circulation of the blood through the heart and lungs.

Veterinary medicine was placed on a modern formal basis with the founding of the first veterinary school at Lyons, France, in 1762. A new era in veterinary medicine had begun.

America

America had been discovered. There were no native domestic animals except the dog; the horse had become extinct in the Western Hemisphere long before. Columbus brought no animals on his first trip; but on his second trip, he brought several. These were supplemented by the animals of DeSoto, Pizarro, and Cortez.

During the first hundred years of this nation's existence, Indians practiced better veterinary medicine than the white man. They cropped ears and docked tails of horses, sutured with buckskin thongs, shoed with leather. After the founding of the French and English veterinary schools, we began to take a greater interest in animal medicine. Ezra Cornell established the first veterinary department in this country, while the first veterinary college was a private one in Philadelphia. America then embarked on an era of vast veterinary expansion. By 1900, the Bureau of Animal Industry and the American Veterinary Medical Association had been formed; shortly afterward, the first veterinary journal began publication. On June 30, 1906, Congress passed the law requiring Federal inspection for cleanliness and wholesomeness, by graduate veterinarians, of all meat moving in interstate and foreign commerce. This was to be the golden era of the private veterinary school. They were located all over the country, with a curricula lasting from several months to two or three years.

The American Expeditionary Force in France during World War I focused attention on the veterinary activities of the American army and the American veterinary educational system. It was the impression of the Surgeon General that veterinary curricula should be intensified and the course of study lengthened. The private schools began a rapid decline and were quickly replaced by land-grant colleges in the years immediately following 1918. The increased use of mechanization spelled the end for the old-time "horse-doctor," but cattle, poultry, swine, sheep, and pet animals received increasing attention and more than filled the gap.

The doctor of veterinary medicine is now required to complete six years of university training, comparable to that required in other branches of medicine. Rigid veterinary licensing requirements have upgraded the profession. There are now seventeen veterinary colleges in the United States, graduating nearly 1000 students yearly. There are approximately 17,000 graduate veterinarians; 14,000 in practice, 3,000 in government service. There are over 3,000 registered small animal hospitals.

Past, Present, and Future

Animal-medicine has made tremendous progress. Within our own memory, the veterinary profession has transformed itself into a highly organized body prepared to control infectious disease on a nationwide basis. In no other country do so few oversee the health of so great a number of animals that feed and clothe so many, both here and in far away lands.

Broadened medical and social perspectives have taken the veterinarian beyond the limitations of patient-orientation into preventive medicine and public health work . . . into the United States Department of Agri-

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Blood . . . A Circulating . . .

• By Eric Ellenbogen, Ph.D., (*Harvard University*)
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This article was originally entitled "The Blood —a Circulating Chemical Plant." The author chose the present title in order to avoid stressing one interpretation of the totality of the blood.

We recommend that you carefully study this article.

●

I

Certain caves located in southern France are famous for the paintings of mammoths found on their walls. Within the outlines of these animals there are drawn red spots, indicating the position of the heart. The drawings were made some 25,000 years ago by modern man belonging to the Cro-Magnon race and represent the earliest record of man's knowledge of the importance of heart and blood. However, we may safely deduce that man's earlier ancestors must also have been aware of the importance of the blood and its pump for the maintenance of life, even though we have no records to support this deduction.

Much has been written in ancient books and documents about blood, and many hypotheses had been advanced concerning its origin, function and purpose, but it was not until the year 1616, that the English physician William Harvey began lecturing on his discovery: blood circulates! In the years since that memorable day we have made tremendous strides in this field of scientific endeavor and many mysteries concerning blood can now be explained in terms of fundamental laws of physics, chemistry and biology.

In this essay we shall first "take apart" the whole blood and discuss briefly its components in terms of their chemistry and physics. This will allow us to "put it together" again, and to look at it in terms of a complete system which carries out many functions necessary for life and activity.

II

Let us look at average man weighing 70 kilograms (154 pounds). His blood accounts for approximately 8 per cent of his body weight and occupies a volume of about 6 liters. On the average, the specific gravity of blood is 6 per cent higher than that of water (1.060). The circulation of the blood is maintained by the pumping action of the heart which will produce an average of 26.5 billion pulses during man's average life (72 pulses/minute for 70 years). Blood is composed of two phases, fluid and corpuscular. The corpuscles are uniformly suspended in the fluid which is called plasma. They account for one-half of the total weight of the blood, but since their specific gravity is greater than that of the plasma, they occupy only 45 per cent of the volume of blood. If we look at them under a microscope, we can distinguish between three major types of corpuscles, called red cells (erythrocytes), white cells (leucocytes) and platelets (thrombocytes). One cubic millimeter of blood (one thirtythousandths of a fluid ounce) contains an average of 5,000,000 red cells, 8,000 white cells and 300,000 platelets. These figures are generally lower for females, but the normal variation is sufficiently wide to allow us to choose this particular set for our average man.

Each red cell circulates through the body once every 30 seconds. A total of 30,000 billion red blood cells circulate constantly at a rate of about 100,000 trips per month. From isotope studies we have learned that the average life span of a red cell is 120 days, after which time it is destroyed. Since each red cell contains 0.03 millimicrograms of a red substance called hemoglobin, and since 250 billion red cells are destroyed daily, this means that approximately 7.5 grams of hemoglobin are destroyed by the body each day. Since the organism must continue to function efficiently, however, an equivalent amount of hemoglobin and red cells are manufactured each day in order to maintain balance.

The function of red cells is by far the best understood compared to the function of the other cellular components of blood. Suffice it to say here that the main function of the white cells and platelets is defensive. White cells in general combat infections by acting directly on foreign organisms, and platelets function by forming a blood clot whenever the circulating system is damaged. Much more important, however, is the role of the various proteins which are dissolved in the plasma.

Plasma is a yellowish fluid containing approximately 70 grams of proteins per liter. These proteins are substances whose molecular weight is thousands of times heavier than that of the water in which they are dissolved. In addition to these large molecules, a number of salts and other organic molecules are also present in the form of their ions. Some of these are sodium, potassium, calcium, iron, phosphate, bicarbonate, glucose, amino acids, uric acid, and so on. In the following discussion we shall limit ourselves to the role and function of the plasma proteins, of which some sixty have so far been identified.

The plasma proteins have physical properties similar to other proteins. When subjected to very high gravitational fields (about 250,000 g) they can be separated from each other and from the smaller molecules surrounding them. Each one of these proteins is made up of hundreds of amino acids which are linked together

Table I

Protein	% of Plasma Proteins	Biological Function
Serum albumins	52.	Binds fatty acids, dyes, drugs, mercury, water, bile salts
α_2-Glycoproteins	1.2	Combines with carbohydrates and barium
α_2-Mucoproteins	0.5	Combines with carbohydrates and barium
Fibrinogen	5.	Combines with thrombin to form clot
Cold insoluble globulin	0.15	?
α_1-Lipoproteins	3.	Combines with steroids and carotenoids and phospholipids
β_1-Lipoproteins	5.	Combines with steroids and carotenoids and phospholipids
β_1-Lipid poor Euglobulins	3.	?
β_1-Metal combining protein	3.	Combines with iron and copper ions
β_2-Globulins	3.	?
γ-Globulins	11.	These are the antibodies which are formed against foreign agents
Prothrombin	0.1	Combines with calcium ions and thromboplastin to form thrombin
Plasminogen		Combines with streptokinase to form plasmin
Hypertensinogen		Combines with renin to form hypertensin
Iodoproteins		
Isoagglutinins	0.03	Blood grouping substances, combine with incompatible red cells
Complement components	0.4	Function with the antibody-antigen complex
Amylase		Digests starch
Choline esterase	0.005	Acts on choline esters
Alkaline phosphatase		Hydrolyzes phosphate esters
Peptidase		Splits L-leucylglycylglycine
β-Glucuronidase		Hydrolyzes β-glucuronides
Caeruloplasmin		Binds cupper ions
α_1-Small Acid protein	0.5	?
α_1-Bilirubin globulin	0.05	Binds bilirubin
α_2-Protein	0.1	Reacts with barium ions
β_1-Protein	0.05	?

in such a manner as to impart specific shapes and sizes to the individual protein molecules. There are about eighteen different amino acids available to the body and the body's synthesizing mechanism utilizes a certain number of each kind and links them in some specific manner to build up the whole molecule. Since one may have millions of combinations and permutations in which eighteen amino acids may be linked together to give a molecule with a total of hundreds of amino acids, many properties can be imparted to such large molecules. One of these properties is that of electrical charge distribution. This means that protein molecules may possess both positive and negative charges. Consequently, when one immerses a positive and a negative electrode into such a protein solution, and when one then causes a direct current to flow through this solution, the proteins which have more negative than positive charges will travel to the positive electrode, those having more positive than negative charges will travel to the negative electrode, and those having an equal number of positive and negative charges will not move at all. Furthermore, for example, those molecules having 20 more negative than positive charges will travel faster to the positive electrode than those having only an excess of 10 negative charges. In this way, we may separate the various protein molecules according to the number of charges they possess, and this property gave rise to classifying the plasma proteins into five groups according to their mobility in an electric field. On this basis, 50% of the plasma proteins fall into the albumin class, 15% into the alpha-globulins, 19% into the beta-globulins, 11% into the gamma-globulins, and 5% into the fibrinogen class. In the foregoing table are listed the properties of many known plasma proteins.

The above list accounts for a little over 88% of all plasma proteins. Our average human body has a total of about 230 grams (7.6 ounces) of these proteins in circulation. Each one of them lives an average of 8 to 28 days. This means that the body breaks them down and resynthesizes them continuously. In other words, none of the constituents of blood ever suffer from wear or tear; the normal maintenance mechanism of the body insures that only 'fresh" proteins circulate. We might cite the analogy of a large city tearing down each house and rebuilding it every twenty years. By means of these proteins, the blood fulfills the functions described in the following section.

III

We are now in a position to understand the role of blood in terms of the parts played by its components. Although all of the activities of blood are important,

we may single out as the most important one the role of blood in the maintenance of respiration. Respiration is the fundamental activity of the living body—without it none of the specific events requiring the presence of blood will take place. Respiration is the role assigned specifically to hemoglobin.

Hemoglobin is a red protein containing iron. Within the red cell it is dissolved in water containing many ions, such as chloride, potassium, bicarbonate, phosphate, magnesium, calcium, sodium, and others. Its principal role is that of mediating the respiration of the organism by transporting oxygen from the lungs to the various tissues, and removing from them carbon dioxide which is transported to the lungs to be exhaled into the atmosphere. Hemoglobin has a molecular weight of 68,000, and during its lifetime it transports 1,000 times its own weight of oxygen and 1,500 times its weight of carbon dioxide.

The role of hemoglobin in the maintenance of respiration resembles that of an ion exchanger. Broadly speaking, the following reactions occur when oxygen is given up to tissues and when carbon dioxide is removed from them. The carbon dioxide to be exhaled diffuses from the tissues into the blood. Since blood is a two-phase system, the gas enters first into the plasma. The gas is only slightly soluble in water and therefore only a very small amount reacts directly with water to form carbonic acid, which is neutralized by sodium ions to form sodium bicarbonate. Another small portion of carbon dioxide reacts with (basic) amino groups belonging to plasma proteins to form carbamino compounds and hydrogen ions. By far most of the carbon dioxide, however, diffuses through the plasma into the red blood cells. There, a biological catalyst, an enzyme called carbonic anhydrase, brings about the reaction $CO_2 + H_2O = H_2CO_3$. Since this reaction is catalyzed, almost 90% of the carbon dioxide can be brought into solution inside the red cells. Broadly speaking, the carbonic acid formed in this manner is neutralized by potassium ions attached to oxygen-carrying hemoglobin to form potassium bicarbonate and hydrogen ions. At the same time a molecule of oxygen is liberated which now diffuses through the red cells and through the plasma into the tissues. The remaining 10% of the carbon dioxide which diffuses into the red cells reacts with amino groups of oxygenated hemoglobin in a complicated manner resulting in the liberation of more oxygen which also diffuses into the plasma and then into the tissues. During these reactions, the state of chemical neutrality inside the red cells is disturbed. Balance is restored by causing bicarbonate ions to diffuse out of the cells into the plasma in exchange for chloride ions and water molecules. All of the above reactions are reversed when the blood reaches the lungs. There it takes up oxygen which diffuses into the red cells where it is bound by the hemoglobin for ready release to the tissues during the next circuit.

Blood is a regulatory agent. It is the instrument which executes orders given by the brain to the rest of the body. For instance, in the brain is located a small gland, the pituitary. It manufactures minute amounts of organic molecules and small proteins, known as hormones. These hormones, and they alone, can stimulate other organs and glands in the body to produce certain substances, or to carry out certain functions. Whenever the brain gives an order, or whenever the pituitary gland (often called the master regulatory gland) acts to bring about a certain event, it will release a hormone into the blood stream. This hormone will then circulate throughout the body and will eventually reach the gland which is to be stimulated. In general, these hormones will attach themselves to the serum albumin molecules which will transport them. In this manner, the blood regulates body processes by transporting regulatory substances.

Blood maintains the state of neutrality of the fluids which bathe and surround the body cells. In general, the blood is so slightly alkaline (pH 7.4) that it will not change the color of neutral litmus paper, and for all practical purposes can be considered neutral. Many reactions which occur in cells, however, release either acid or base, and unless these products of metabolism are neutralized, severe damage would be suffered by these cells. The plasma proteins, in conjunction with the inorganic substances present in the plasma, have the unique property of being able to absorb rather large quantities of acid or base from the surrounding medium without themselves becoming acid or alkaline. Respiration is one of the many reactions which relies on the ability of the blood to maintain a state of neutrality. Of the plasma proteins, the serum albumin is by far the most effective acceptor of excess acid or base.

Approximately 70% of the body's weight is water. This amount of water is normally kept constant, yet it is constantly in motion. During digestive processes, for example, as much as 14 liters of water pass through the intestines. Water is constantly ingested in foods and with foods, and water is constantly lost—in the feces, in urine, in sweat and by evaporation through the skin. Water molecules take part in all biological reactions which make up the total metabolism of the body—water is used up in reactions such as hydrolysis and water is produced in reactions such as the synthesis of proteins. The blood regulates the constancy of the water content by two hydrodynamic processes. In its circulation, the blood passes through very tiny vessels, called capillaries, of which the body has some 100 billion with a total surface of about two acres. Since the blood is pumped through the body under pressure, passage through the capillaries tends to expel water molecules from the blood into the tissues. The plasma proteins, however, have a great affinity for water molecules, and they in turn tend to withdraw water from the tissues back into the blood by a process called osmotic pressure. Of the plasma proteins, albumin is by far the most efficient protein, and it is the protein most directly concerned with the withdrawal of water from tissues. This fact is utilized in medicine in the treatment of shock and in the therapy for edema. Shock is often the result of excessive blood loss, and the administration of concentrated albumin solutions tends to restore water balance. Edema or swelling is

a sign of excess water in the tissues, and here administration of albumin will result in the withdrawal of this water from the tissue and in its excretion through the kidneys.

The ready availability of water through the blood makes also possible close temperature control of the body, in spite of extreme variations of environmental climate. Water has a very high specific heat. This means that water requires a large amount of heat before the temperature rises appreciably. Water is also a very good thermal conductor and has a very high latent heat of evaporation (the evaporation of water requires much heat). This heat is withdrawn from the environment which will therefore be cooled. Evaporation through the skin cools the skin and the blood circulating in the skin is also cooled. By virtue of its good thermal conductivity, heat is exchanged between the periphery and the interior, and the inner portions of the body are also cooled. When normal evaporation cannot remove enough heat, the body begins to sweat and the evaporation of the sweat will increase the removal of more heat through the skin.

Blood is the agent which transports nutritive factors throughout the body. Nutrients derived from foods are absorbed into the blood stream from the gastrointestinal tract and are transported to those tissues which require them for normal functioning. Blood will also transfer a nutrient manufactured in one part of the body to another site where this nutrient may be used in some specific fashion. In addition to this transport mechanism which is quite analogous to the distribution of goods between manufacturer and user, the plasma proteins themselves have a high nutritive value. In emergencies, the body can draw on the plasma proteins for food, but plasma proteins are not utilized as nourishment until all other food and energy reserves of the body are exhausted. As soon as the emergency is relieved, the body will then manufacture first its depleted plasma protein stores before other stores are built up again.

Closely related to the distribution and transfer of nutrients is the cleansing activity of the blood. Since all metabolic processes of the living organism produce unwanted byproducts which in many cases are toxic, it is very important that they be removed as fast as possible. This is accomplished in many ways, of which a series of two consecutive steps is fundamental. First, toxic end products of metabolism are brought into the liver where they are rendered harmless. Secondly, these harmless products in addition to others which do not pass through the liver, are brought into the kidneys. There the blood is filtered, the harmful or waste products are removed from the blood, and the purified blood is returned into the circulation. Excretion is accomplished in the urine.

Finally, the blood is able to perform protective functions. The gamma-globulins, constituents of the plasma, provide protection for the living organism against certain infections. They act essentially by neutralizing the causative agents by means of reactions which essentially block their damaging activities. The gamma-globulins are well known for their protective action against polio viruses, against measles, whooping cough, and against infectious hepatitis. These proteins may be formed by immunization against an agent, and will generally remain available to the body against this organism for long periods of time. In addition to this protective action, the blood will protect the body against loss of life brought about by excessive bleeding. This phenomenon is well known, since it is observed by every living organism. We refer to the formation of the blood clot. Clot formation is a very complex process, but the following brief discussion will illustrate the process.

The liver manufactures two proteins, fibrinogen and prothrombin, which are then excreted into the blood stream where they become part of the large family of plasma proteins. Production of prothrombin is enhanced when the body has sufficient vitamin K. When a blood vessel is pierced, the platelets presumably release an enzyme called thromboplastin. This protein, in addition to calcium ions present in the plasma, as well as a substance called accelerator globulin and other yet unidentified platelet substances, activates the prothrombin and transforms it into thrombin. Thrombin can now react with fibrinogen to form fibrin clots. Clots sometimes form within blood vessels, or in the brain, precipitating acute and near fatal conditions. The enzyme plasminogen, also present in the blood, may be activated into plasmin which in turn can act on fibrin clots to produce soluble split products which can be excreted. This process of dissolving internal blood clots is rather slow, and for this reason recovery after coronary thrombosis, small embolus, or stroke is slow.

IV

The preceding paragraphs gave a picture of some of the coordinated functions of the blood. A thorough understanding of these functions enables the physician to rectify metabolic defects, to combat disease, and to effect cures for many illnesses. There is one drawback to the use of whole blood in therapy, however. In order to utilize some specific property of a component of blood, large amounts would have to be administered in order to derive the benefits due to the presence of a particular component in small amounts. For example, a child may be protected against infection by measles with an intramuscular injection of 2.0 ml of a γ-globulin solution containing 165 mg/ml of this protein. This relatively small injection contains the same amount of γ-globulin as 75 ml of whole blood. A patient suffering from shock might receive an intravenous injection of 50 ml of 25% serum albumin, equivalent to approximately 750 ml of whole blood. Thus, whole blood for the last patient would waste enough γ-globulin to protect 10 children against measles. It became necessary, therefore, to devise chemical methods which would separate the various plasma proteins

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Life Underground

• By Brother G. Nicholas, F.S.C.
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How many and how varied are the forms of life existing in the depths of damp and dark caves? How do these forms of life obtain their food supply?

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If you were to pick up the morning paper tomorrow and read of the discovery of a hitherto unknown island in the mid-Atlantic, you would undoubtedly be interested in learning what type of life existed on the island. Should you read further and learn that this island was over a thousand square miles in area then there would be even greater enthusiasm amongst naturalists to investigate the new forms living there. Strangely enough, there is in the United States today an area far greater than our postulated isle which has been seen by no more than a few dozen scientists, let alone thoroughly explored. This is the underground region existing in the approximately 50,000 caves in our country. Some of these caves that have been surveyed contain passages totaling over a score of miles. Others are so small that man has been unable to squeeze into them. Yet all contain life and the forms taken by this life make the study of cave animals and plants one of the most fascinating aspects of speleology.

Since a universal feature of life is its adaptability to practically any environment on earth it is not strange that caves should possess whole populations of creatures that have existed longer than some epigean forms. The individual conditions influencing cave biota are not unusual since life is reported from these various contributing factors to the cave environment in other types of surroundings. The perpetual darkness of caves is duplicated by the continual lack of light in the ocean depths, where life is abundant. The food supply of caves, which at first glance would seem to be non-existent, is no more restricted than that of Alpine mountain tops where birds, beetles and bacteria are found.

In most caves the humidity is constant, approaching 100 per cent. This high humidity enables aquatic organisms to leave their pools of water and travel over the moist cave rocks and formations in search of food and for reproductive purposes. Such is the case with eels and many amphibians which travel surprisingly long distances through moist fields and over damp rocks. Cave temperatures vary little from a fixed mean except near the entrance where sunlight and air currents affect this uniformity. Again, the depths of the sea can serve as the example of a habitat where the temperature is table. Even the alkalinity of the water in limestone caves is not so great as to differ from the pH essential for life.

All animals need food to survive. Yet, since no animal can make its own nourishment, it is dependent on the plant, which using the light of the sun as a source of energy, can convert the raw materials of carbon dioxide, water and mineral material into the starches and sugars which are the basis for animal nutrition. This synthesis is accomplished with the aid of the pigment chlorophyll. Without this substance there would be no life for all living things depend on it, directly or indirectly. However, chlorophyll is never found in the darkness of a cave since there is no sunlight to energize its food making ability.

Photosynthesis is not foreign to cave creatures however, since it is the plant material brought into the cave from the land of light that is the basis of their existence. Water is the primary avenue of transportation for the plant material. Streams wash in colloidal material which originated in plants. Rain water frequently carries in leaves, logs and humus plus other organic debris. Even water seeping in from the surface through the overlaying rock carries dissolved organic material. Other sources of transportation for this nu-

FIGURE 1. The cave biologist frequently has a difficult time studying cave life. Muddy clothes, hard helmet and mountain climbing equipment are essential in exploring a cave.

FIGURE II. Flatworms found in many caves of the United States live on organic material dissolved in the water.

trient material are those inhabitants of caves which depend on outside sources for their food. Bats, which feed on insects, supply a rich source of food in their droppings. Bat guano is found several feet thick in some caves and on it grow fungi and bacteria. The droppings of animals whose dens are found near cave entrances, such as skunks, racoons and cave rats, also support insect forms and fungi.

Thus, having established a basis for a food cycle, the existence of numerous worms, insects, small crustaceans, isopods, snails, fish, salamanders and frogs is to be expected. Cave dwellers are both aquatic and terrestrial. The former are usually lacking in pigment and either have no eyes or their eyes are non-functional. Platyhelminthes, or flatworms, stretch their flattened white bodies into many odd shapes as they twist and glide through the water in cave pools. They are carnivorous, feeding on insect larvae, smaller isopods and decaying organisms. They possess unique powers of regeneration, since these planaria may be subdivided into as many as six parts and within several weeks each part will have regrown those parts necessary for a complete specimen. This may be a means of reproduction, but they can also reproduce sexually. The planaria serve as food for the fish and crustaceans of the cave.

Other aquatic creatures include the isopods, or water lice, which feed on fungi and guano; amphipods, related to shrimp but for the most part smaller than these crustaceans; *Daphnia*, or water fleas, which are practically invisible but can be detected when a light is shone upon the water as so many white specks flitting about; even hydras and sponges have been reported flourishing in sink hole caves.

Crayfish are among the largest of creatures living in water that are adapted to cave existence. They feed on insects, millipeds and smaller arthropods. The blind crayfish have an acute tactile sense, aided by elongated antennae or feelers. Some investigators feel their sense of smell is also more highly developed than in surface forms. Blind cave fish in general are smaller than fish found in streams and lakes, being no more than two or three inches in length. *Amblyopsis spelaeus* is larger and may reach six inches in length. In the United States cave fish are to be found mainly in Kentucky, Indiana, Illinois, Missouri and Arkansas. No case of cave fish being found north of the southernmost limit of the glaciers is known. Presumably all caves beneath the ice sheet were flooded so that no food or oxygen could have gotten into the cave. Since the ice sheets have retreated only comparatively recently cave fish, and other true cave forms as well, have not had time to re-establish themselves.

The outstanding group of cave amphibians are the salamanders. Over a dozen species are known that either live permanently in caves or spend long portions of time there. In the United States, six species have been reported that are troglobites; *i. e.*, true cave animals that never leave the cave. Larvae, possessing gills, develop from eggs laid in the water and live in the water until maturing into the adult form. Not all cave salamanders are white; some forms are speckled or spotted. Even the colorless salamanders have a pinkish tint due to the network of blood vessels near the surface of the body. These blood vessels are necessary for cutaneous respiration. The salamander breathes through its skin as well as its lungs. Frogs may be found in caves but none are troglobites. They are attracted from the outside by the insects and other sources of food or are washed in by water from the surface.

Terrestrial forms of cave fauna are mainly arthropods. Centipedes, springtails, moths, beetles, spiders, harvestmen, mites, water scorpions, various kinds of flies, beetles, crickets, and fleas are among the types reported as existing in caves. Very few of the numerous species found can be considered troglobites, since most of the above mentioned organisms either leave the cave at certain times for food, or their presence is accidental since they prefer any suitable dark place as a habitat. These latter types cannot be distinguished from their non-cave dwelling cousins. As in other classes of animals, true cave insects have no eyes, or at least they are non-functional. Their antennae are long, and occasionally the whole body is covered with hairs to supplement the feelers.

Mollusks are found in caves and include such forms as snails and slugs. Whether any such specimens should be considered as natives of caves is debatable since they normally live in a damp, dark region even above ground. Those that are present in caves play a part in the food chain of the cave as they feed on decaying plant material and are fed upon by salamanders and perhaps frogs.

Few birds make their homes consistently in caves, although owls and phoebes are sometimes found in nests in the twilight zone of the cave. The guacharo or oil bird *(Steatornis caripensis)*, found in a large cave near the village of Caripe in Venezuela, is the only strictly cave bird. It leaves the cave only at night

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The Keystone Visual-Survey Service

• **By G. E. Hamilton, M.A. Oxon.**
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Poor classwork and disciplinary problems can be frequently traced to the student's faulty vision. The correction of visual defects demands a vision-screening program that uncovers all defects in vision.

The Keystone Visual-Survey Service, usually referred to as the "Telebinocular(R) Tests," has been developed during the past twenty years in answer to a wide demand for screening tests that would give more information concerning the vision of school children than that provided by the use of the Snellen Chart. The development has been made with the assistance and advice of educational psychologists, optometrists, and ophthalmologists. Every step has been carefully checked and rechecked again and again. Criticisms have always been thoughtfully considered and appropriate revisions made when such revisions seemed to be indicated. Today more than 3000 school systems and more than 350 colleges and universities use these tests. More than 3000 industries use the Telebinocular for testing applicants for employment and re-testing periodically the vision of all workers. Thirty-two states use the Telebinocular for testing all applicants for drivers' licenses. The Keystone Telebinocular Tests have achieved outstanding acceptance in the educational world, which is highly indicative of their merit and value to the eye health of our young people.

Educators demand a vision test that not only covers the broad aspects of vision but a test that also takes into account both the study needs of the student and his general vision needs as well. Educational experts have long recognized that visual factors other than acuity often affect adversely a child's development. In order to compensate for such functional difficulties the child may become a behavior problem, he may seek to avoid school activities that demand good visual coordination, or he may be overwhelmed by the problem of learning to read. A school vision-screening program should uncover any and all visual functional problems so that the child may, if necessary, have professional attention that will enable him to function as a normal child—and achieve normal development into a well-integrated member of society.

What Is the Keystone Visual-Survey Service?

The service consists of the No. 46 Visual-Survey Telebinocular, fifteen stereographic test cards, a set of Non-Language Charts for demonstrating to young pupils, a manual of instructions, record forms and parent's notification forms.

The fifteen stereographic cards provide information on the student's visual efficiency covering a wide field of important functional aspects of vision. Instead of testing visual acuity by occlusion, the usable vision of each eye is tested with the other eye open and seeing. Tests are provided to determine whether or not the student has coordinated vertical posture of the eyes, acceptable lateral posture, fusion, depth perception, and adequate appreciation of red and green colors. Since the student does most of his work at approximately sixteen inches, tests for usable vision, lateral posture, and fusion are given at the equivalent of sixteen inches as well as at the equivalent of twenty feet. Although usable vision at far point may usually indicate the status of usable vision at near point, it frequently happens that the far-sighted student will show troublesome exophoria or fusion difficulties at near point. Old-fashioned ideas to the contrary, educators know that near-point tests are important.

The Importance of Binocularity

The Keystone Tests stress the importance of binocularity. The two eyes must work together if the student is to have comfortable, efficient vision. If they don't work together, if fusion is difficult or impossible, then extreme discomfort and confusion follow or suppression of vision in one eye. Either of these outcomes, of course, is most undesirable. It is obviously very important, therefore, that school screening tests disclose binocular difficulties in addition to monocular visual acuity. It is important, furthermore, that ophthalmologists and optometrists understand such problems and include these problems in their professional examination.

The problem often arises as to what the ophthalmologists or optometrist can do about problems of poor binocular coordination if such a condition is discovered. In 1912 David W. Wells, M.D., eminent ophthalmologist, said: "A recent review of 1000 cases of eyestrain shows that 25% needed treatment because of some failure of the two eyes to work together properly. Since each person is obliged to learn the art of using the two eyes together as part of his own experience, and has no instruction whatever, some of us learn it well and some of us learn it quite imperfectly." Dr. Wells gave his patients binocular eye tests and followed that up with appropriate binocular-training procedures designed to alleviate or correct the lack of good binocular functions[1]. Since that time leading ophthalmologists and optometrists have devoted more and more attention to visual training as a part of their professional service. Since the Keystone Visual-Survey Service stresses binocular testing, it is very important that doctors to whom students are referred understand the implication of such tests and what can be done where the tests disclose lack of good binocular function.

Record Form and Standards

A profile-type of record form is provided for use with the Keystone Visual-Survey Tests. Standards for referral are indicated on the basis of the educational needs of the average student and on the basis of standards commonly in use by the ophthalmic professions. However, the record form is so constructed that any school or system can alter these standards to meet local requirements.

Referrals and Over-referrals

Closely related to the interpretation of the record form is the question of over-referrals. From time to time someone reports a study or writes an article indicating that the Keystone Tests, as well as other types of binocular tests, refer students for professional eye care who are reported by the doctor to need no professional eye care. It is very important, therefore, to give the tests carefully and to follow the instructions in the manual, which provide that the tests be given a second time before a referral be made. This repetition of the tests will often disclose the fact that the failure on the first testing was the result of misunderstanding or sometimes the result of some temporary lapse on the part of the student.

In considering the matter of referrals and over-referrals it should be noted that the purpose of a screening test is "to detect those individuals who should have an examination by an eye specialist." A test over-refers only when the condition noted does not exist. There is no over-referral simply because the doctor may indicate that no immediate remedial measures are necessary. If the deficient condition as shown by the screening test exists, the determination of the effect of the condition or its need for immediate remediation is the province of the professional eye-care specialist and involves professional judgment, as well as measurement.

On the other hand such reported over-referrals may sometimes be due to the limitations the doctor puts on his practice. If he is one of the old-fashioned doctors who merely prescribe lenses and are interested in no functions of vision other than monocular acuity, he would, of course, report a student referred because of wide exophoria or lack of fusion, and nothing else, as in no need of eye care. Differences in the standards of ophthalmologists were reported in 1954 by a special Committee of the New England Ophthalmological Society. We quote from this report: "A preliminary survey of positions by the questionnaire method has indicated that a considerable difference of opinion exists among ophthalmologists in regard both to their office practice and to their desires in regard to the standards which they would set for the referral of school children to them."[2]

The suggestion is made from time to time that schools set up their own vision clinics and give complete eye service. Many doctors assert that they cannot afford to give visual training at a price that the ordinary parent will pay. It is possible in some cases that the parent isn't able to pay for such services. In other cases it is possible that the doctor, although believing in the importance of visual training, is not able to convince his patients of the need for such eye care. An educational eye clinic would render these services at a nominal cost or in cases of need at no cost at all. It would seem more desirable, however, that the ophthalmic professions develop ways and means of handling this matter of complete eye care in a way that will permit the schools to give reliable screening tests and refer to ophthalmologists and optometrists students needing eye care, feeling satisfied that complete services will be rendered.

In the matter of parents objecting to charges made in the case of over-referrals, it would seem possible for the doctor to have his assistant check on the screening test or run a quick screening test in his office and avoid in this way the necessity for a complete visual analysis. The late Dr. Richard B. Scobee wrote for "The Journal of Ophthalmology" in 1952 an article defending high over-referrals as preferable to under-referrals. He also warned ophthalmologists against overemphasizing with parents the matter of over-referrals. He warned against their blaming the teacher or nurse who had made the over-referrals and against criticizing the kind of tests the schools were giving.[3]

The matter of proper referrals and the limitations of over-referrals can usually be settled on a local level by the school people, the ophthalmologists, and the optometrists getting together and deciding what in that community could be regarded as satisfactory vision. Where this has been done, and it has been done in hundreds of communities, the problem of over-referrals sinks into insignificance.

Research

In no other field of health is reliable research more difficult to obtain than it is in the testing of vision. In the first place, as stated above, there are no universally accepted standards as to what acceptable vision should be. In evaluating binocular vision, reference to any Snellen standards is not valid. Furthermore, in Snellen findings the gaps are too wide—for example 20/20, 20/30, 20/40, etc.,—for any sort of statistical evaluation. Although there have been many studies of the Keystone Visual-Survey Service related to the reliability of the tests, it has been practically impossible to attempt research in order to establish validity.

Experience has to a large extent filled in this lack of research. As suggested above the large number of schools, colleges, and industries that have used and are continuing to use the Keystone Tests with satisfaction is a strong indication of satisfactory performance. It is inconceivable that the colleges, universities, and great corporations, all with competent health departments, would use and continue to use a series of tests that does not give usable and dependable guidance in their concern for eye care. As experience and verified information accumulates ultimately, of course, standards of all the important functions of binocular vision may be developed and accepted universally. Snellen

standards had to be set up arbitrarily and have never been altered.

Time Required to Give the Tests

Sometimes objections are raised to the time required in giving the Keystone Telebinocular Tests. This becomes important in school systems where the tests are given annually or even biennially. It must be understood that we are dealing here with an important aspect of the student's school life, and it would seem too bad to deny the valuable service involved merely because personnel or time is too limited to handle the matter properly. Recently a three-card Short Test has been released. This test is conducted on a "yes-or-no" basis and can be given in less than one minute. It may be used as a sort of elimination test. A student who can pass this test readily and without a single failure may be safely excused from any further screening test with the Telebinocular. It has been found that this Short Test will eliminate about 50% of the students in the average school from taking the complete test. This test can be used to great advantage where there is need for cutting down the time of giving the Telebinocular Tests to an entire school or to an entire school system.

In some school systems parent-teacher organizations have taken over the giving of the Telebinocular Tests. There are many others in the community who can readily be trained to give the tests and who are quite willing to make this contribution to the health services of the schools. It is desirable, if possible, that referrals made in such mass testing be retested by a nurse or by some well-qualified teacher before final referral to the doctor is made.

As school administrators become more and more aware of the importance of safe-guarding the vision of their students, the demand for adequate vision-screening tests and for complete visual care by the professions becomes more insistent. The sole objective of the Keystone Visual-Survey Service is to help meet these needs. ●

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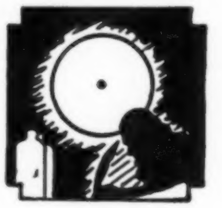

The Electromagnetic Spectrum

Of all the forms of energy known to science, none is more useful to man nor more diversified in its range of application than electromagnetic energy. The heat from the sun, light and color in all its forms, electrical power, radio waves, ultraviolet radiation, X-rays, and cosmic rays are all varieties of electromagnetic energy. These varieties have two aspects in common: they may be transmitted through space as a wave motion, and their speed of transmission is constant—186,000 miles per second.

The primary differences between these various forms of energy are the frequency of their characteristic wave vibration (the number of waves passing a point per second) and the length of the waves (the distance between successive wave crests). Yet when frequency is multiplied by wave length, the result is always the same—the velocity of light.

The spread of different forms of electromagnetic energy arranged either in order of decreasing wavelength or increasing frequency provides a continuum known as the electromagnetic spectrum.

The range of wavelengths included in the electromagnetic spectrum is enormous—from hundreds of miles down to less than a trillionth of an inch. In only a very small part of this range—that of visible light—are man's senses sufficiently developed for accurate perception of electromagnetic waves. In all other wave length regions science has had to develop special equipment and techniques for determining the characteristics of electromagnetic energy in order to apply it effectively to human use. Some regions of the spectrum, such as the frontier area where highest-frequency radio waves overlap infrared, still remain relatively unexplored because of the inadequacy of existing methods and techniques for producing and studying these waves.

The lowest-frequency electromagnetic waves are the electric waves which accompany the flow of electric current through a wire. Here wavelengths are very long: 3100 miles for ordinary power frequencies of 60 cycles per second.

Radio waves are produced in much of the same way as electric waves, but they are shorter and more easily controlled, ranging from a few miles for low-frequency radio down to about an eighth of an inch for the extremely high-frequency microwaves. They are used not only in broadcasting—AM, FM, and TV—but also in radar, air and sea navigation, and various kinds of communication systems.

Infrared waves are produced in all types of matter by the vibrations of charged atoms and are detected as radiant heat. This form of energy is used every day in cooking food and heating homes. Wavelengths range from 16 thousandths to 30 millionths of an inch.

Visible light is usually produced by vibrating electrons in the outer parts of atoms.

Within the short range between 30 millionths and 16 millionths of an inch is included all radiation that can normally be perceived as light—from the longer wavelength red to the shorter-wavelength violet.

Ultraviolet waves are the same type of radiation as visible light, but they cannot be detected by the human eye. They are present in the sun's rays and in the radiation produced by commercial sun lamps. Wavelengths extend down to 16 ten-millionths of an inch.

X-rays have extremely short, penetrating wavelengths ranging from a few ten-millionths of an inch to less than a billionth of an inch. They are produced deep within the atom by the motion of tightly bound electrons and nuclear charges. When produced in the disintegration of radioactive materials, they are known as gamma rays.

Cosmic rays are highly penetrating rays of unknown origin reaching the earth from outer space. Their wavelengths extend without known limit far below a trillionth of an inch.

—*Bureau of Standards, Open House, 1955*

★ ★ ★ ★ ★

Analyzing Nuclear Reaction

(Continued from Page 128)

separation merely replaced chemical separation and the problem of atomic number (rather than atomic weight) determination remained. The growth rate of a longer-lived daughter can be used to measure the yield of a short-lived product.

The determination of the massive reaction products has usually been left to the chemist who uses the techniques outlined thus far. The physicist has followed the production of protons, deuterons, alphas, etc., by placing detectors near or in the cyclotron during the actual bombardment. The detectors may be photographic plates, cloud chambers, or scintillation crystals. The cyclotron's magnetic field is used as a mass separator. Identifications are made by studying the resulting photographic plates in the first two instances, or, when scintillation detectors are used, by measurement of the resultant pulse height. In all cases the nature of the accelerator's magnetic field must be known in order to make complete use of the other data. The number of events recorded gives the yield.

What are the results of the several types of analysis described so far? If thermal neutrons are employed as projectiles, the target atom will capture one and enter an unstable, excited state. The excess energy is usually lost by gamma emission, leaving a new isotope that may be stable or radioactive. In a few cases, e.g. U^{235}, fission results leading to a whole range of products. The U^{235} reaction has, of course, been most extensively studied. It has been found to lead to asymmetric fission, i.e. masses 90 to 100 and 132 to 145 are most probable while 117 is at the intermediate minimum—down a factor of 7000 from the peaks. Higher energy neutrons seem to give a more symmetrical result.

Charged particle bombardment leads to more possibilities. At low energies there will only be a change of one or two in mass or charge of the target atom. But at high energies any nuclide is a possible product from hydrogen up to the sum of the target and the projectile. The only restriction is that enough energy must be present. Heavy element bombardment with 2 Bev protons produces Be^7 in significant yield! The physicists observations of the light fragments show that protons, neutrons, deuterons, alphas, and even heavier "chunks" are knocked out of the nucleus by the incident projectiles.

Analysis of all the experimental data suggests a nucleus consisting of individual neutrons and protons residing each in its own energy level. But sufficient interaction exists to make a liquid-drop model sometimes useful. No picture capable of predicting accurately the course of a given reaction has yet been devised. At present, particularly careful, accurate analyses are being carried out to study small effects in the overall product picture. ●

Blood . . . *A Circulating* . . .

(Continued from Page 134)

into clean fractions containing only a certain type of protein, in order to utilize efficiently the rather small amounts of human blood available.

Separation of the plasma proteins is achieved by working at low temperatures, from freezing to about minus 10 degrees Fahrenheit, and utilizing pure grain alcohol in conjunction with other physical conditions. The fractionation scheme is rather complex, but it achieves the separation of many substances in pure enough form so as to economize and make more efficient the proper utilization of our blood resources. These separation processes allow the preparation in stable form of many blood proteins in concentrated solutions, so that relatively small amounts will be as effective as large volumes of whole blood. Of the many proteins listed in Table I, only a relatively small number has wide clinical use, but this is due more to our ignorance concerning the functions of many proteins rather than their biological role. Of those which are listed, only a relatively small number has been purified to such a degree that one can characterize these molecules.

Let us dwell briefly on the biological function of those proteins listed in Table I which we have not yet discussed. In addition to the important role which serum albumin plays in the maintenance of water balance and neutrality, it serves as a very efficient transport vehicle. Many drugs which are administered to a patient, such as sulfa drugs, or penicillin, are specifically bound by serum albumin and are released to the tissues where they are intended to do their job. Many dyes which are injected into the blood stream for diagnostic purposes are bound by serum albumin and this enables the physician to visualize many organs by means of X-rays. The glycoproteins and mucoproteins combine with carbohydrates, and may be considered as transporters of these substances throughout the body. Nothing is known about the cold-insoluble globulin. When plasma is cooled to near freezing, a protein precipitates out which goes back into solution when the temperature is brought back to normal. The lipoproteins combine with fats and steroids and in this way fats are solubilized. Ordinarily, fats cannot be dissolved in water, but the binding to the lipoproteins solubilizes them, and they can be transported efficiently through the body. The β_1-metal combining protein has a specific function, the uptake of iron. It transports iron molecules throughout the body, and is essentially the only mobile and ready reserve for this metal which is so essential for the formation of hemoglobin. So essential is iron, that the body cannot excrete it and can lose it only when hemorrhage or other losses of blood occur. Little is known about hypertensinogen and the iodoproteins.

The isoagglutinins are substances which react specifically with incompatible red cells. The blood of the population of the world contains four different types of red cells, types A, B, O and AB. If a blood transfusion with A blood is given, for example, to a patient whose blood belongs to type B, death often results because clumps of aggregated red cells clog the blood vessels. The substances responsible for the clogging can be isolated and are known, and are now used routinely in the typing of blood in order to prevent mishaps due to the mismatching of donor blood. The role of the complement components in the blood is very complex, and still not quite clear. Amylase is an enzyme which digests starches. Choline esterase is an enzyme which hydrolyzes choline esters, a substance involved in certain types of nerve actions. Similarly, peptidase and β-glucuronidase are specific enzymes. Very little is known about caeruloplasmin, α_1-small acid protein, α_2-protein and β_1-protein. The α_1-bilirubin globulin is a protein which binds bilirubin, a substance formed when red cells are destroyed. The bilirubin content of blood is in many cases a diagnostic index of proper metabolism.

Our discussion would be incomplete if we were to omit some of the information which we possess concerning the size and shape of these molecules. Some of the physical-chemical methods employed in these studies were mentioned earlier. In Table II are listed the molecular weights and shapes of the better known plasma proteins.

Table II

Size and Shape of Plasma Proteins

Protein	Molecular Weight	Shape and Dimension in Angstroms (10^{-8} cm)
Serum albumin	65,000	ellipsoid, 150 A long, 40 A thick
β_1-Metal combining protein	90,000	ellipsoid, 190 A long, 38 A thick
β_1 Lipo-protein	1,300,000	Sphere, 185 A diameter
Fibrinogen	330,000	ellipsoid, 700 A long, 35 A thick
γ-Globulins	156,000	ellipsoid, 240 A long, 40 A thick

There are many other proteins, where either the molecular weights are known, or where we know the ratio of length to thickness, but other data are not yet available to characterize them as fully as the ones listed in Table II. In order to visualize these dimensions, suffice it to say that the water molecule is a sphere about 2 Angstroms in diameter. On this basis, these proteins are many hundreds of times larger than water, and thousands of times heavier (water has a molecular weight of 18). For comparison consider the shapes of some proteins shown in Figure 1, where the molecules are depicted on a relative scale.

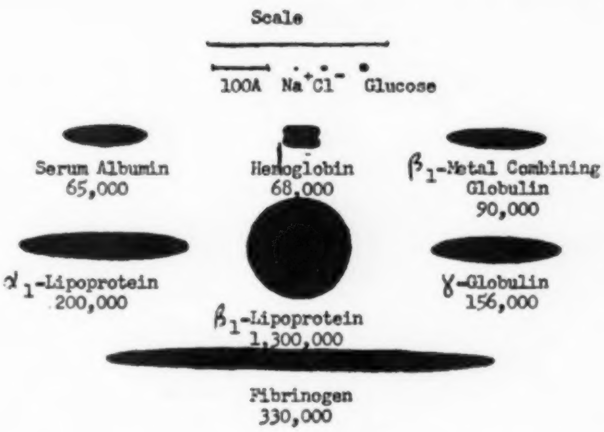

FIGURE 1. Relative dimensions and molecular weights of various plasma proteins (from J. L. Oncley).

Very often blood has been likened to a circulating chemical plant, but this is actually only one interpretation of the totality of this fluid. From its varied functions, one may consider it a transport system, a circulating sanitary system, a mobile repair shop, and so on. Blood is truly a unique fluid and as a consequence is rather complex. Regardless of the systems to which we may liken it, the integral function of blood places it above any analogous facility or industrial or political entity which man could ever devise. ●

The Science Seminar

(Continued from Page 123)

VIII. Chemistry and Physics "Open House"

A. Student demonstrations of the principles and applications of the following instruments:

1. Bausch and Lomb Spectronic Colorimeter (hemoglobin determination)
2. Cenco Oscilloscope (visual recording of sound waves produced by the human voice)
3. Fisher Titrimeter (chemical analysis by "electric eye" titration)
4. Demonstration Geiger Counter (counting emanations from radioactive samples)
5. Chemical Kinetics (demonstration of an apparatus improvised by the Head of the Division of Natural Sciences at St. Joseph's and used by him for research in kinetics)

As stated previously, the Seminar evolved naturally, having been initiated by a need. Its evolution is by no means complete, and those concerned with its organization and implementation are convinced that it possesses a far-reaching educational potential. Utilizing the resources of the college faculty, outside authorities, student ability, audio-visual aids, and group discussion, broader horizons will open to students and faculty alike, as they become increasingly conscious of the necessity of integrating knowledge from a variety of fields in order to obtain satisfactory explanations of single phenomena. ●

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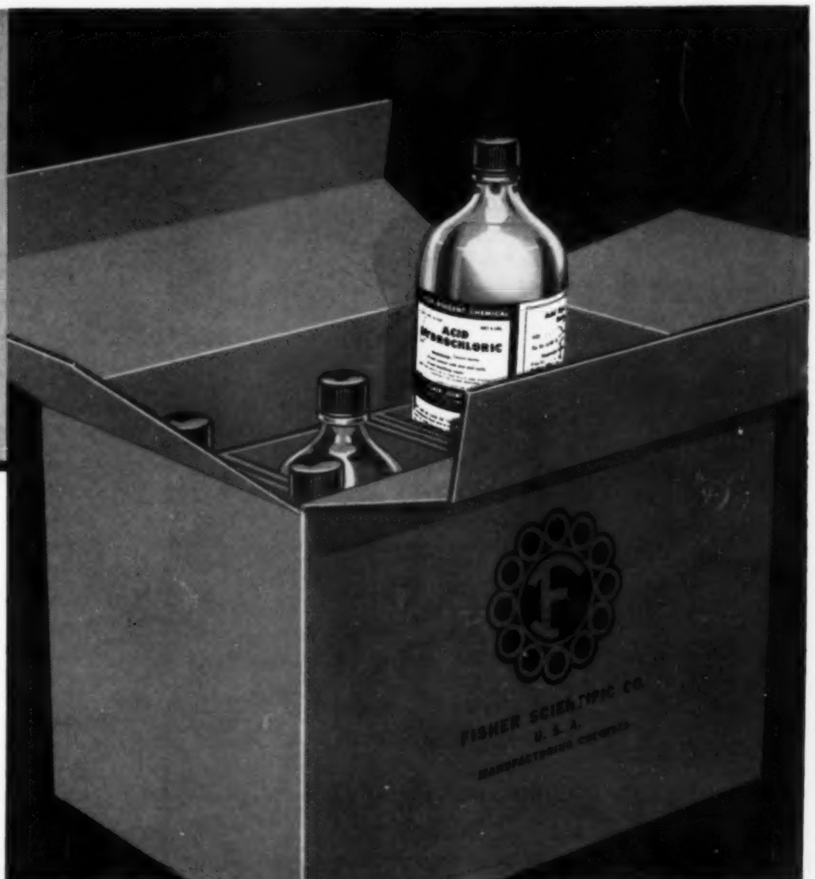

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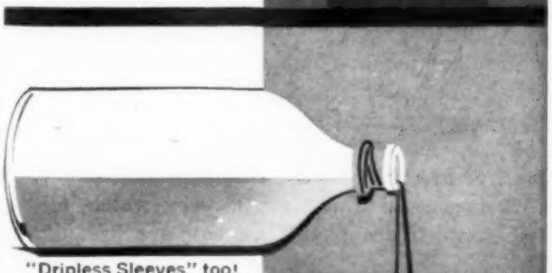

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Life Underground

Continued from Page (136)

and returns before dawn. These birds, which have a wingspread of four feet, live in absolute darkness more than a thousand feet from the entrance. The young are born and roost in nests lodged in crevices of rocks. These birds are able to avoid hitting obstacles while flying in the cave by an acoustic-echo location system similar to that used by bats. Unlike bats, however, their outbursts are audible, having a frequency of 7,000 cycles per second. Since over 5,000 of these birds roost in the cave, the noise is deafening when the whole flock flies in or out.

The most widely known inhabitant of caves and one most frequently observed is the bat. Dozens of species of these flying mammals either use caves as a place of hibernation or occupy them during the time when they are not out seeking food. The use of ultrasonic waves as the sense of location by bats is rather commonly known, although a leading pocket-sized magazine stated several years ago that bats determine their location by radar. Obviously this is incorrect since the bat does not possess the means for either sending or receiving electrical impulses. Instead, the rapidity with which the echo of the call of the bat returns to it determines the proximity of the nearest obstacle. Bats have been blindfolded and yet flown for hours in a room where wires one inch apart stretched from the floor to the ceiling.

Bats usually mate in the fall but the eggs are not fertilized until the end of the hibernation period. The spermatozoa survive in the female until the eggs are freed, which may be four or five months after copulation. The young bat is carried by the mother until it is old enough to fly. Bats do not have true wings but the forelimbs have a membrane attached which enables the bat to fly. Some species of bats cluster in large numbers along the ceilings and walls of the caves as they rest or hibernate, while other species are solitary, individuals being found only singly. They hang head downwards, while their toes clug firmly to tiny crevices in the rocks. In recent years migrations of bats have been studied by means of bat banding. Lightweight metal bands are clamped on the forearm of the bat. It has been determined that bats frequently return to the same cave year after year and several have been reported that were found in the same cave almost twenty years after banding. Ticks, mites, and fleas are occasionally found as parasites on the furry bodies of bats and these could in a certain sense be considered inhabitants of the caves.

Another familiar mammal found underground is the cave rat, also known as the pack rat. These rats leave the cave to forage for food such as leaves, roots and seeds which constitute the main items of their diet. They also pilfer bright objects, pieces of metal, paper and even, on one occasion at least, a wrist watch, all of which are found in the nest. These rats are friendly

and are known to feed at the hand of a man holding tidbits of food.

Contrary to popular opinion, bears are not cave dwellers except rarely when they have been known to use shelter caves during the period of their long winter sleep. Snakes occasionally hibernate in caves but do not use them as regular dwelling places; caves are too damp for these reptiles. Badgers, racoons and skunks frequent the entrances to caves and may sometimes be found in areas of total darkness. Wolves and foxes are also known to use small caves as dens.

The study of early man has revealed that our ancestors made use of caves both as shelter and as sites of worship. The famous cave paintings found deep in the mountains of southern France and northern Spain indicate that man must have been familiar with ways of surviving for short periods of time at least in caves. Even today several "villages" in France and the Balkans have been authentically reported as being nothing more than caves with doorways erected at the entrances. Incidentally, it might be well to mention that the use of caves in the United States as a means of survival from atomic attack is quite dubious. It is true that the rock would serve as an excellent shield from atomic radiations but the difficulties of living in an atmosphere as humid and damp as most caves are would make survival underground even more precarious than survival above ground. Unless caves could be thoroughly ventilated, cleaned of all mud and rock, equipped with means of eliminating waste, heated above the constant temperature of 50°F. in the case of those north of the Mason-Dixon Line and provided with sufficient exits in case the entrance might be blasted shut, it seems improbable that modern man will revert to the habits of his forerunners and return to dwelling in caves. ●

★ ★ ★ ★ ★

Veterinary Medicine

(Continued from Page 130)

culture . . . into the Army Veterinary Corps and Air Force . . . into institutional work at colleges and universities as instructors, clinicians, investigators, and extension specialists . . . into positions with professional journals, zoological gardens, pharmaceutical and biologic manufacturers.

Yet, there is more opportunity and need for veterinarians today than ever before. There are still frontiers to be pioneered. The profession stands on the threshold of a most thrilling decade—one holding vastly greater material benefits to man and animal than has been known since the beginning of time. ●

Correlation of Art

(Continued from Page 125)

Modification of any of these parts is possible with this basic structure.

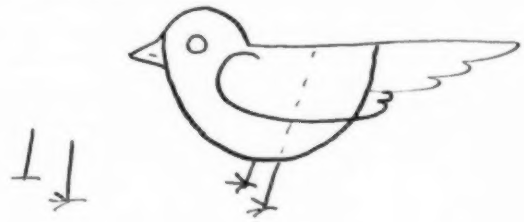

FIGURE 11

In the plant kingdom the common mushrooms and toadstools have been selected for demonstration here. They are practically all formed on the circle or some modification of it. In Figure 12 the steps used in drawing some of these forms are illustrated.

FIGURE 12

Both simple and composite flowers have as basic foundations the geometric forms of circle, semi-circle, and cone. These basic figures can be translated into practically all the forms studied in science courses. In Figure 13 a few forms have been drawn. ●

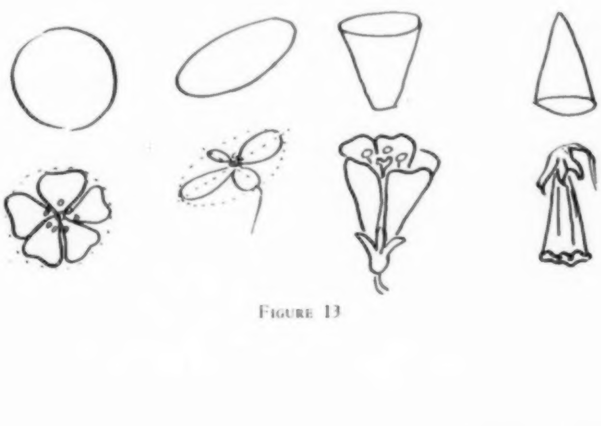

FIGURE 13

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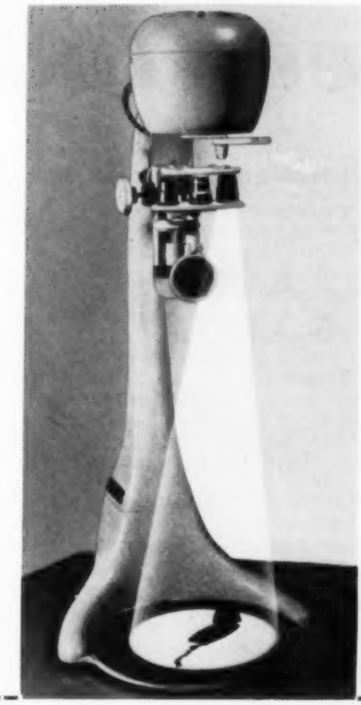

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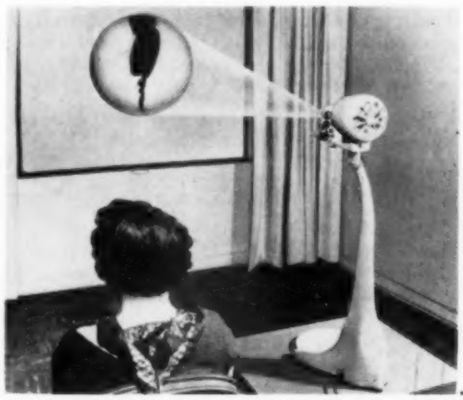

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New Books

Evolution, Genetics and Man

• *By* THEODOSIUS DOBZHANSKY. John Wiley and Sons, Inc., New York. 1955. $5.50

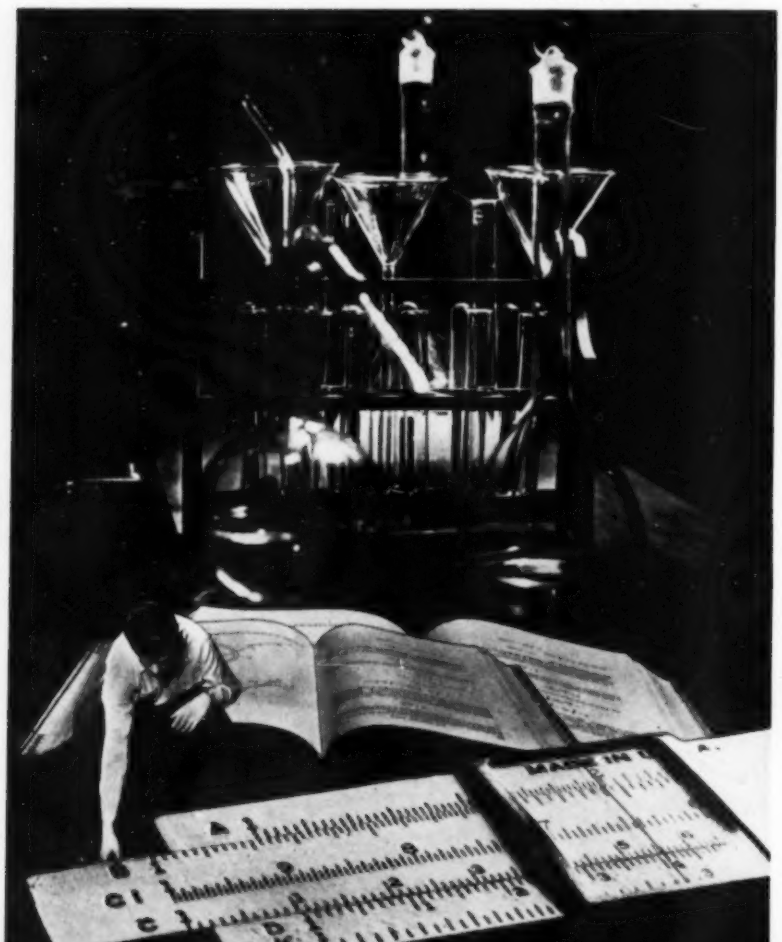
An interesting view of the problem of evolution as seen through the eyes of a genetecist. The gene is considered as a basis for evolution. A mutation in the gene composition of a certain species, followed by a survival and reproduction of the mutant gives rise to an evolution within the species. Evolution within the species has been extended to an evolution from the simplest of organisms to the most complex of species. Man, the prime subject of evolution, is kept in the foreground throughout the book.

Laymen need not fear this book for the early chapters deal with an introduction to Genetics and Heredity and give an understanding of the basic problems of genetics. Also included are events and treatment of evolutionary ideas which give a solid foundation for the understanding of the genetic approach.

The chapters are arranged so as to give the most information with the least confusion. The list of supplementary readings at the end of each chapter can serve to enhance one's knowledge of the subject.

Frank J. Draus
Department of Chemistry
Duquesne University

Photo by VIC KELLY



Taboo

• *By* FRANZ STEINER. Philosophical Library, New York. 1956. Pp 154. $4.75.

Published after the author's untimely death in 1952, this work represents a carefully documented critical analysis of the meaning of *taboo*, from its discovery by Captain Cook among the Polynesians during the last quarter of the 19th century to the present. Steiner obviously consulted all the significant relevant literature on taboo in several languages, and wove it into his own text, examining it in a highly critical and helpful manner.

The book reviews the various methodologies, postulates, hypotheses and theories of anthropologists and sociologists as these touch upon his topic. He subjects each to severe analytical criticism.

Steiner sees taboo as related to the sacred, the prohibited, and at times, to the unclean. He envisions taboo as an element in all situations in which value judgments are expressed in terms of danger behavior. Sociologists will probably disagree with Steiner's position —"that all human relations to value can be expressed in terms of danger behavior on the individual and institutional level." Not a book for beginners, *TABOO* provides the specialist with challenging documentary sources in the sociological and anthropological fields.

Francis R. Duffy, C. S. Sp., Ph. D.
Chairman, Sociology Dep't
Duquesne University

The Curious Art of Autobiography

• *By* H. N. WETHERED. Philosophical Library, New York, N. Y. 1956. Pp. 237. $7.50.

This is a compressed but scholarly book about a representative group of twenty-one famous writers from the Sixteenth through the Twentieth century, representing religion, fiction, science, and art, who achieved literary fame in the art of autobiographical writing.

Concerned only with authors who gained distinction in this form of writing, the author took this reviewer quite pleasantly and informatively into the writings of Cellini and Montaigne of the Sixteenth Century to Benson, Conrad, and Kipling of the Twentieth.

However, the Seventeenth and Eighteenth centuries held the greatest number of author selections.

Bunyan, Baxter, Pepys, Gibbon, Rousseau, Franklin, Lamb and De Quincey are the discussed authors of the Seventeenth century.

Darwin, Borrow, Trollope, Cardinal Newman, Moore, Meredith, Ullathorne and Osbaldeston were the selections for the Twentieth century.

The author claimed that he would have liked to include Chesterton but found him to be one of those artists who forbid condensation.

Believing that it is the past centuries that need additional light thrown upon them rather than the scene around us, the author proceeds to recount the difficulties these writers, in turn, encountered and the steps they took to overcome them.

This was an interesting approach to perhaps the most revealing form of literary writing we have. A mellow and pleasant reading.

C. S. McCarthy
Department of Journalism
Duquesne University

Logic and Scientific Methods

• *By* HERBERT L. SEARLES. The Ronald Press Co. New York. Pp. VIII + 378. $4.25.

This thoroughly modern text is divided into three parts. Part I covers the definition of logic, logic and meaning, logic and language, definition and division. Part II treats the proposition, judgment, categorical and hypothetical syllogisms. Part III is an excellent presentation of the methods of science.

The presentation of the subject is accurate and, unlike most logic texts, interesting. Diagrams and examples are used effectively. In the discussion of hypothetical syllogisms a limited use is made of the apparatus of symbolic logic. Each chapter ends with an interesting selection of exercises and problems.

The scholastic philosopher will probably find some sections not as well developed as in scholastic texts. This is true of the treatment of signs, but, in view of the many good features of the text, this is not a serious fault. A good teacher can easily supply what is missing.

The treatment of the methods of science is excellent. The chapters on probability and statistical methods are much more complete than in most texts and are handled so expertly that these sections alone make the book a worthwhile investment.

The appendix contains the tree of Porphry, suggestions for the solution of some of the problems in the text, a glossary of terms and a selected bibliography. This book should be in science and philosophy libraries.

J.P.M.

A Dictionary of Poisons

• *By* IBERT and ELEANOR MELLAN. Philosophical Library. Pp. 150. $4.75.

The science of toxicology is based on complex and very often poorly understood interactions of a variety of substances with animal cells and tissues which lead to the elaboration of physiological symptons indicative of harmful or lethal effects. Rather extensive and detailed reference works have been published in this field for the enlightenment and guidance of professional personnel engaged in toxicological research and related activities. Few manuals have appeared, however, which outline first aid measures to be followed by the laity in poisoning cases. "A Dictionary of Poisons'" is an attempt to provide such information.

Introductory remarks include a very brief and altogether inadequate discussion of the history of poisons, definitions, general emergency treatment including physical and chemical removal of poisons, methods for preparing antidotes, emergency treatment of burns caused by heat and chemicals, gas poisoning, poisoning by commercial products such as insecticides, fungicides and the like and finally, a rather incomplete list of common household poisons.

The remainder of the volume is devoted to alphabetized monographs of some common and many uncommon poisons. An occasional detailed discussion of the history and some interesting facts concerning better known drugs and poisons is included in the alphabetized arrangement. Very often these discussions are completely void of the usual information found in a typical monograph. Such monographs usually include cause(s) of poisoning, symptoms, and antidote or first aid treatment. Monographs of less than twenty-five words are frequently encountered. All monographs are ended with the advice to "CALL A PHYSICIAN". The caution is well advised because of the brevity of the treatment outlined.

One is at a loss to understand the inclusion of many items. It is well known that sulfonamides are potentially dangerous as are many other drugs used in therapy at the present time; however, one would hesitate to classify them as poisons; or if taken in overdosage to attempt first aid treatment. Numerous inclusions of this type are encountered. It appears that the authors have selected a heterogenous group of substances many of which are better defined as drugs rather than poisons.

This volume cannot be recommended as authoritative. In the opinion of the reviewer, the material is poorly organized and much too abbreviated. Many monographs could have been deleted; others expanded considerably. The book is of questionable value; however, if from its pages the reader gleans enough information to save a life, its publication will be justified.

J. Adams, Ph.D.
DEAN, School of Pharmacy
Duquesne University

Mission on the Nile

• *By* REV. JAMES DEMPSEY OF THE MILL HILL FATHERS. Philosophical Library, New York. Pp. 247. $6.00.

Father Dempsey gives a very clear picture of mission work among the Shilluk people of the Upper Sudan. It is the type of book that only a dedicated missionary could write. The little-known Shilluk tribe comes alive in these pages and the reader is given a comprehensive account of the origins of the tribe, their customs, the history of their land and a detailed picture of their day to day existence.

Throughout the book there is a light touch that does much to sustain interest. There are many missionary anecdotes which give a wonderful insight into the character of the Shilluk people as well as into the character of the author. The accurate descriptions of tribal methods of meting out justice show a keen understanding of the moral and ethical code of these people. The sympathetic treatment of their marriage and birth and death customs is always tempered with a light touch of humor and a shrewd appreciation for the ludicrous whenever this appears.

Father Dempsey goes back for more than a hundred years in relating the history of the missionary apostolate among the Shilluk. He then brings the reader up to date with the progress of the Faith by telling in some detail of the routine work and life of the Priests and Sisters of the mission at Detwok.

The book contains some excellent photographs and a few sketch-maps. It is an excellent study of one tribe and one area as seen through the eyes of an experienced apostle whose love of his work shines through every page of the book. Such informative accounts of other mission territories by missionaries living right on the spot would be inspiring and useful additions to our fund of knowledge of the continent of Africa.

F. Philben, C.S.Sp.
Former Missionary
British East Africa

Sourcebook of Laboratory and Field Studies For Secondary School Biology Courses

High school teachers of biology who are especially interested in improving laboratory and field work in secondary school biology courses are invited to apply for appointment to a group that will prepare a sourcebook of laboratory and field studies for such courses. The project is sponsored by the Committee on Educational Policies of the Biology Council, Division of Biology and Agriculture, National Academy of Sciences-National Research Council, and by Michigan State University, with the support of grants from the National Science Foundation. The sourcebook will be developed at an eight-week writing conference, to be held June 24 to August 16, 1957, at Michigan State University, East Lansing, Michigan.

It is generally agreed that stimulating instruction in laboratory and field is a vital part of a rewarding high school biology experience. Giving students opportunities to conduct observations and experiments on plants and animals arouses interest, deepens their understanding of living systems, and provides experience with scientific methods of inquiry. Unfortunately, despite its importance, laboratory and field study is too often pedestrian and unimaginative. One way to improve the situation is to supply teachers with a collection of superior exercises, realistically adapted to high school situations. All teachers could then use procedures developed by particularly capable teachers. This is the purpose of the sourcebook, which will contain a series of complete exercises from which individual teachers can draw ideas, studies for particular topics, or the laboratory and field work for entire courses.

The material will be developed by a group of 20 high school teachers and 10 college and university biologists. The prime requirement for participants is a creative, imaginative approach to laboratory and field studies. All interested high school biology teachers are invited to apply. Biologists and school administrators are also urged to submit the names of teachers who are well qualified for the assignment. Each applicant or nominee will be sent a form asking for information on his background and experience, and evidence of his ability to contribute to the preparation of the sourcebook. The final selection will be made on the basis of two essays submitted by each applicant who passes a preliminary screening. One essay will illustrate how a topic supplied by the Committee can be converted into a study for high school use; the other will present an exercise the teacher has devised. The purpose of the essays is to give the Committee on Educational Policies a basis for judging applicants' ability to conceive and write stimulating laboratory or field studies.

The essays will also form a part of the pool of ideas for the sourcebook. Manuscripts so used will be credited to their authors, who may thus appear in the publication even if they are not selected to participate in the Conference. The writing team will also have access to other collections of exercises, including those gathered by the Committee in preparing a series of sourcebooks of laboratory and field studies for college courses in the biological sciences.

The Committee has already selected the college and university participants. This is a group of successful teachers of introductory courses. Highly skilled in developing laboratory and field instruction, they are experts in different major areas of biology, share a sympathetic understanding of secondary-school problems, and possess personal qualities that make them helpful and creative contributors in a group enterprise.

Each participant will receive a stipend of $1,000. His round trip travel expenses between his home and East Lansing will also be paid. From the stipend he will be expected to pay his own living expenses during the Conference. The University will provide housing and dining facilities at reasonable prices for teachers and their families. For leisure hours the campus and the surrounding community and countryside offer a wide variety of recreational and cultural resources.

In preparation for the Conference the Committee has asked a panel of outstanding high school biology teachers to develop topical outlines for modern secondary-school biology courses. The outlines will supply a framework for the sourcebook, but should also be directly useful to teachers. Members of the panel are Arthur J. Baker, Community High School, Crystal Lake, Illinois, Chairman; William Jones, Handley High School, Winchester, Virginia; Paul Klinge, Howe High School, Indianapolis, Indiana; Joseph P. McMenamin, Oak Park and River Forest High School, Oak Park, Illinois; Brother G. Nicholas, La Salle High School, Cumberland, Maryland; Miss Florence Gardner, West Orange High School, New Jersey.

The Conference will be directed by Dr. C. A. Lawson, Head of the Department of Natural Sciences in the Basic College at Michigan State, and a member of the Committee's Subcommittee on Publications. Participants will have access to ample laboratory and library facilities. Exercises developed by the Conference will be tested in a variety of high schools during 1957-8, revised as necessary, and published by the fall of 1958, under the auspices of the Academy-Research Council.

Completed applications should be submitted by January 31, 1957. All correspondence concerning the project should be addressed to:

Committee on Educational Policies
Division of Biology and Agriculture
National Research Council
2101 Constitution Avenue, N.W.
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